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EDITORIAL

'Standards are essential to our prosperity as a trading nation. We need Standards to keep our industries competitive and to help us create jobs.' These were the words of the Prime Minister at the opening of the British Standards Institution's (BSI's) Quality Assurance Services at Milton Keynes, and reflect the Government's commitment to help companies adopt Quality Methodology. British Telecom (BT) is in the forefront of the campaign to extend the total quality concept to service industries as well as manufacturing industries and is in the process of implementing a company-wide total quality management programme to give continuous improvement of quality to its customer services. BT is a Registered Firm of Assessed Capability with the BSI Quality Assurance Services and the BSI has already issued more than 130 Certificates to BT. Quality is important in all the individual systems and procedures that make up a service, and is not just a superficial gloss on the end product. An article on p. 60 of this issue of the *Journal* shows how care taken in specifying user requirements for computer systems not only builds quality into the system, but can also lead to substantial savings in cost.

On one or two occasions over the past 80 years, minor changes have been made to the layout of the *Journal*; a further change has been incorporated in this issue of the *Journal*. Readers' comments are invited on these changes and, indeed, on the content of the *Journal* and the *Supplement* as a whole so that the *Journal* might better serve your needs in a rapidly changing technological environment.

Beating the Competition—Organising to Win

Keynote Address to the Institution of British Telecommunications Engineers

M. BETT, MA.†

UDC 654.01

This address was given by Mr. M. Bett, Managing Director of British Telecom (BT) Inland Communications, to the London Centre of the Institution of British Telecommunications Engineers on 16 September 1986. In his address, Mr. Bett described how the organisation of BT is evolving to meet the challenges of the new competitive environment.

INTRODUCTION

Hanging on the wall of the Finance Director of a large electronics company that nearly went bankrupt is a Chinese proverb which, roughly translated, says: 'He who has problems in a company organises and reorganises and reorganises again. Reorganisation distracts the eye, but does not solve the problem'.

Companies with deep managerial problems are all too often characterised by rapid changes in the organisation in the belief that commercial problems are due to weaknesses in the organisation. This can be true, but more often than not, business failure is actually due to putting organisation before strategy. Organisations are supposed to deliver strategies, not the other way around. Since we are evolving what may seem to many a second reorganisation in as many years, I just wanted to reassure you that we are doing it for a purpose and not to distract us from getting to the heart of the challenges and problems we face. In fact, the changes being put in place now are a natural evolution following the 'Districtisation' of the business. And these changes are being made so that we can better serve our customers. Only by perceiving the customers' requirements and by raising the quality of our performance, will we beat the competition.

ORGANISATION

The first stage of the development of the organisation of today's British Telecom (BT) devolved operations to the levels where they could most effectively and economically be carried out. The objective was to take decision-making closer to our customers so as to be more directly sensitive and responsive to their needs. The changes were also designed to help all of us in BT, managers in particular, to break away from the habits developed in the administration of a monopoly. We did not have time nor the resources to take a more measured, structured approach within which we could provide training and management development on a systematic basis to underpin the direction in which we were headed. The truth is, that reorganisation served its purpose and brought us all positive benefits. It has forced everyone of us to look at how we do our job as customers' expectations rise and competition progressively enters all parts of our business.

However, whilst operational decisions had been devolved from the centre, it became clear that there remained the need to control overall strategy and to give overall direction to the way in which our UK telecommunications business was moving. First, the split between the local planning of the network and trunk network planning, while enabling us to press ahead with the modernisation of the trunk network faster than we would have been able to otherwise, did have its disadvantages; an indivisible network was divided and inadvertent unproductive internal rivalries developed. Second, organisational divisions in the apparatus business were causing us to operate less than efficiently because there was no end-to-end control of the business. Thirdly, the customer was becoming increasingly confused because a number of distribution channels were being used for similar products because there wasn't a single distribution strategy for the customer premises equipment business. Finally, the work of Sydney O'Hara and his study team on major customers' requirements revealed the extent of the competitive threat; in that context we were not managing our forward strategy coherently. The Local Network Strategy Task Force also showed how we were missing revenue earning opportunities amongst our residential customers.

In short, in each of these key areas of our business, we have now had to evolve the organisation in order to ensure that there are managers within Headquarters who are responsible for the policies of those activities and accountable for their implementation.

† Managing Director, British Telecom Inland Communications

The evolution of the organisation therefore provides single interfaces for each of the Districts, at the centre, with each of our main lines of business. Thus, responsibility for the overall planning of both the trunk and local network lies with John Tippler; Martin Glazebrook is responsible for the choice of customer premises equipment and the determination of the least cost route to the market; and Sydney O'Hara and Jerry Stockbridge are responsible for developing business opportunities to sell our networking capability to our business customers and our residential customers respectively. Nick Kane is responsible for the account management of our most important business customers and for the professional direction of our unified sales force. And, not a product line but possibly most important in the long run, Ron Back chairs the Network Strategy Committee which plots our way into the latter half of the next decade and beyond, developing our greatest physical asset to which all our product lines relate.

All this may seem as if we have been doing no more than tidying up some loose ends. In fact, the reorganisation is consistent with an analysis of the state of the telecommunications and electronics industry.

BT's COMPETITIVE POSITION

Growth in the electronics industry is increasingly fuelled by information technology's capacity to solve problems, defined in day-to-day users' terms rather than those of the computer or communications professional. Users expect the technology they are buying to be 'cheaper' as the price per function falls in response to the capabilities of the hardware. The consequences of this are that hardware suppliers are becoming increasingly capital intensive (and so too are software suppliers as new tools are developed) because achieving greater functionality in hardware depends upon increasingly sophisticated production techniques.

As the price of microprocessors has fallen, the functionality of each unit has grown, so computing costs have fallen. Digital public switching parallels the computer experience, which is hardly surprising since central switches are essentially real-time computers.

The consequences of this 'technological driving force' are to fragment the business activities normally associated with fully vertical integrated companies. Or, put another way, the 'value-added chain' is becoming segmented and specialised.

The semiconductor business, for example, is concentrated increasingly between semiconductor design houses which work to the design rules of semiconductor manufacturers, and the manufacturers themselves, which are highly capitalised, recovering costs through high-volume/low-margin output, distributed through independent distributors. At the other end of the chain, companies such as ICL have selected vertical markets to which they supply integrated solutions (for example; retailing, banking and so on). Their competitive advantage lies in understanding how to apply the most advanced technology (in ICL's case, bought in from Fujitsu) to meet vertical market requirements. This has become known as *solutions selling*, when hardware and software are configured to meet users' needs.

It is in this context that Cable and Wireless's strategy must be seen, and that too of IBM, EDS and GEISCO, amongst others. Currently, Cable and Wireless is taking technology advantage to be a cost-competitive carrier and network operator; its medium-term path is to sell 'solutions' to obtain higher value added from the network. Since this involves entry into customers' premises beyond the end of the network, they require access to such users, and are therefore making links with 'solutions' suppliers such as ICL. This is partly an offensive strategy, to take revenue not just from BT but other public switched telephone networks (PSTNs); it is also a defensive strategy in that computer suppliers are (for the technological reasons described above) already becoming 'solutions' suppliers to meet customer requirements, part of which involves adding value through national and international networking. The advantage computer companies have is that they are already embedded (through account management) with users. They can also provide high-speed advanced networks which PTTs have not been traditionally in business to provide.

Cable and Wireless's relationships with EDS and ICL are most important, because they operate in vertical markets to which Cable and Wireless's network can be highly targetted, at premium prices. It is a cash generating strategy to provide resources to stay one step ahead.

BT's competitive strategy in the UK is revealed in the recent reorganisation which provides the capability and mutual support to enable a comprehensive portfolio of products and services to be supplied to our customers. Now our task is to be quick enough to use this capability to sell solutions into vertical markets, which will often include international networking capacity, to meet the specific needs of major customers.

All our customers expect from us solutions to meet their requirements. By solution, I mean an understanding of his or her requirements and the relevant hardware and software to meet those requirements. For a major business customer, it may be a private circuit of very high bandwidth, coupled with hardware and software beyond the end of the network on his own premises, the value of which is enhanced by the fact that distant locations can communicate with each other.

This does not apply to our major customers alone. As plant is modernised, our residential

customers have equally high expectations of new network services. We have to be able to provide hardware to residential customers which gives them access to new network facilities. One problem is that as prices of equipment come down, we have to find cheaper ways of getting the product to the customer—possibly our major single problem.

Competitive advantage increasingly lies in organisational capability; that is, the ability to put a project together, taking hardware and software from a number of internal and external sources and pulling the bits together to provide a solution to meet the customer's requirements. Our organisation, all relevant aspects of it, has to be capable of responding quickly, flexibly and effectively to the collection of differing demands which go to make up each project.

For us to succeed in this will demand a radical change in our behaviour and in our management processes. In simple hierarchical organisations, management is relatively straightforward. At worst, you do what your boss tells you to do, and he or she does what he or she is told to do by his or her boss! In the better run of such organisations, there are systems for defining jobs, the objectives and goals and the responsibilities, but it is not strictly necessary to do this for such a company to muddle along quite effectively.

But in the matrix organisation we are introducing in BT, exclusively hierarchical relationships no longer apply.

For example, you may be a product line manager in the customer premises equipment business. First, you will have profit and loss accountability for your line of business, but you cannot have direct control over all elements of this costs; some are incurred in Districts, some are incurred in the provision of support services such as computing or transport. But you do have the task of getting a handle on all those costs and determining the least cost route to the market which will give BT a reasonable return on the sales of the product; you may need to recommend changes in distribution strategy to remain in the particular market, for example. Second, you may find you have to meet a number of competing needs. For example, a national account manager may require delivery of a product on a particular day as part of the total contract BT has entered into; the product line manager has to ensure delivery to meet the contract's requirements; but equally, the national account manager has to be certain before the contract is agreed, that BT does have everything required to meet that contract, consistent with where our best interests lie overall.

If you extend this, it will often be the case that a number of Districts will be involved in supplying parts of a total network solution to the customer's requirements; these too, have to be co-ordinated and each District committed to delivery on the day promised.

We are not, therefore, a relatively simple organisation where accountabilities and responsibilities are vested in the same line of management, and dependencies are defined hierarchically, but one where relationships may differ laterally and vertically from job to job.

We should not underestimate the depth of change in behaviour this requires. Our most sophisticated competitors have taken 20 or 30 years to reach this state of evolution. Their management and their employees are conditioned to accept that they do not have everything they need to meet customers' requirements under their direct control, but they do have access to everything that is needed.

The simple fact is that, if you are a systems company as we are, the organisation has to be capable of designing, implementing and delivering systems. Individuals have different responsibilities for different parts of the system, but are dependent upon each other if the system is ultimately to work.

The successful operation of such a matrix depends not only upon behaviour, but upon powerful management processes to underpin that behaviour. Central to these processes is a planning system which holds the parts together.

PLANNING SYSTEM

The planning system is driven by the overall strategy of the so-called *UK TelCo* and this is the responsibility of the Inland Communications (IC) and Business Services (BS) Management Boards. The Management Boards have collective responsibility for the overall development of the policies to be pursued. Thus, although each member of these Management Boards has designated functional or line responsibilities, these are discharged within the framework of a collectively developed and agreed policy. This leads to a relatively unstructured decision-making process in the development of strategy and relatively structured and disciplined implementation. The advantage of such an approach is that although policies may take some time to develop and agree, the iteration of regular and detailed discussion leads to full understanding of strategy and rapid implementation once decisions are made.

The first tenet of planning is therefore that overall strategy is the responsibility of the Management Board. The plans needed to carry out that strategy are the responsibility of the managers and successful realisation of the strategy depends upon management's readiness to plan. Planning is not therefore something to be carried out in bureaucratic isolation. It is the day-to-day responsibility of managers and its effectiveness depends upon the extent to which it is accepted as a management tool.

This relationship between operational managers and planners defines the role of planning. First, planning is concerned with the establishment of a disciplined framework within which at defined points in the course of the year, managers appraise and re-appraise, in the light of prevailing external and internal factors, their objectives, the policies to realise them and their product and service plans. The objective is to arrive at a 5-year forward look which will keep the business moving forward consistently rooted in a budget for plan year 1, on which a manager can be committed to deliver an agreed performance at year-end.

Second, planning is the means of testing the validity and integrity of management intentions: it is in this sense an intellectual tool. The planning activity provides the means of testing the quality and coherence of management's medium- and long-term objectives and developing a common understanding of those objectives.

The onus to plan lies with each unit manager, the line man responsible for driving an activity forward. The planning function gives form and shape to the unit manager's objectives. This is not to devalue the role of planners. The task of giving expression to a manager's business opportunities and how they are going to be tackled is not a static process. It is an essential element in an iterative process which brings out the inconsistencies of thinking, and pulls together the different perspectives and contributions of those reporting to the unit manager so that a coherent view is shared by his team.

It is the planning process which glues the parts of the company together.

The first stage is that of business appraisal. Within the context of an overall strategic marketing plan, developed between the business units and approved by the IC and BS Management Boards, the business units develop their forward product and service plans. These form the basis on which the Districts can build, bottom-up, an appraisal of the immediate market for those products and the likely volumes for them as well as all those actions necessary to get the product or the service to the customer. At the end of this business appraisal stage, which gives us a top-down and bottom-up perspective, we enter a second phase where the Board can set against that background a strategic plan.

This draws upon the business appraisals and takes account of broader external environmental factors including City expectations as expressed by corporate and other major strategies open to us. Once the strategic plan for the TelCo has been agreed both by the IC and BS Boards as well as by the Corporate powers that be, then agreements can be reached on resource allocation and will be made between Headquarters and each of the business units and Districts so that the objectives of both business units and Districts can be brought into coincidence. Resources will be allocated by priority to products and service plans of recognised strategic importance; key planning parameters, sales, profit, capital employed, capital additions and cash flow will be agreed.

When these agreements have been reached, the business units and the Districts will carry on to the third stage and compile their business plans and budgets bottom-up. Business plans will cover 5 years. The revenue budget will be plan year 1 and the capital budget will cover the full 5 years. Both business plans and budgets will be submitted at the end of October. They will then dialogue through to reach an agreed position by the end of the year.

The planning process therefore provides the discipline to make the matrix work for us. If we do not make this work, we shall be competitively disadvantaged. It is up to us.

CONCLUSION

That's how my lecture officially ends. But I would like to finish on a different note. There are good organisational systems and bad ones; that is, inappropriate for the purpose. But no system will even half work without the commitment of the people and the managers both to the organisation, and to each other in the interests of the organisation. And you need good quality people to make a system work well.

I'm very pleased to be able to say that we have a growing commitment to mutual support among my senior colleagues. And we certainly have the quality. If there is one thing that I, a relative newcomer, have noticed since joining BT, it's the quality of the staff, managers and managed, that are committed to the welfare of BT and its customers.

That's why I'm sure we'll beat the competition.

Biography

Michael Bett was educated at Aldenham School and Pembroke College, Cambridge. He was Director of Industrial Relations at the Engineering Employers's Federation from 1970–1977 and Personnel Director of the BBC from 1977–1981. He has been a member of the NEDO Working Party on Large Construction Sites, the EE Management Board, the Pay Board, the Committee of Inquiry into the UK Prison Service, the Training Levy Exemption Referees, the Committee of Inquiry into the Water Dispute, The NHS Management Enquiry and the Employment Policy Committee of the CBI. He is currently a member of the Manpower Services Commission and the Armed Forces Pay Review Body. He is a Fellow of the British Institute of Personnel Management and a Companion of the British Institute of Management. He is a member of the Court and Council of the Cranfield Institute of Technology. He became BT board member responsible for personnel in April 1981, and was appointed Managing Director of Local Communications Services in October 1985 (which became Inland Communications in June 1986).

The Verification Test System

P. A. WARREN, B.SC.†

UDC 621.395.7 : 621.395.66

This article describes the verification test system, a telephone exchange facility tester which gives greater flexibility than any presently available equipment. As new exchange types provide more numerous and complex facilities, the system can be made capable of testing them in any environment from initial design through to maintenance.

INTRODUCTION

The verification test system (VTS) is a flexible facility tester for private automatic branch exchanges (PABXs) and public exchanges.

The VTS exercises a target exchange from a telephone user's viewpoint, by having access to the peripheral ports of the target exchange. The system does not attempt to measure software resource loading or other parameters which would not be perceivable by a telephone user, although equipment to monitor such parameters may be connected to the exchange while the VTS is in use. The VTS emulates the actions of a human user (for example, lifting a receiver and dialling a string of digits), and monitors the responses of the exchange (for example, the connection of call progress tones or ringing current).

For many years, the above features have been incorporated in test call senders of varying degrees of sophistication. However, the VTS terminates many more ports on the target exchange and, by use of a controlling computer, can enable the testing not only of bi-directional signalling paths without interconnect variation, but also the complete testing of more complex facilities such as conferencing, diversions, enquiry, shuttle, etc.

Since it is computer-controlled, VTS testing is reliable, repeatable, flexible and can be carried out without supervision.

HISTORY

The VTS was originally conceived by Teltone Corporation (Washington, USA) as a development test aid for a PABX. British Telecom (BT) has negotiated a licence in respect of the concept and has developed the system considerably to widen its range of applications and to reduce its cost.

APPLICATIONS

As a result of the enhancement of the original system, the VTS now has applications in the following PABX and public exchange areas:

- System development
- End of production line testing
- Commissioning and installation
- Service and maintenance
- Repair

In addition, it is possible to test any target exchange having analogue ports (even if the target's common-control circuitry is digital) with minimal software changes.

Because the VTS is modular and flexible, it can be used for many applications which were not originally envisaged. Some of these may be achieved by software changes; others may require the design of a new card. Two of these new applications (multiple call card and line monitor) are described in this article.

PHYSICAL SYSTEM

VTS hardware consists of an enclosure containing VTS printed wiring boards (PWBs) and a controlling microcomputer. The VTS cabinet size is dependent on the user's requirements and is usually provided in one of three standard sizes which cater for 128, 512, or 1024 ports maximum. As a guide, a 128-port VTS (as shown in Figure 1) is enclosed in a cabinet about 500 mm by 500 mm by 300 mm high. There is no theoretical limit to the

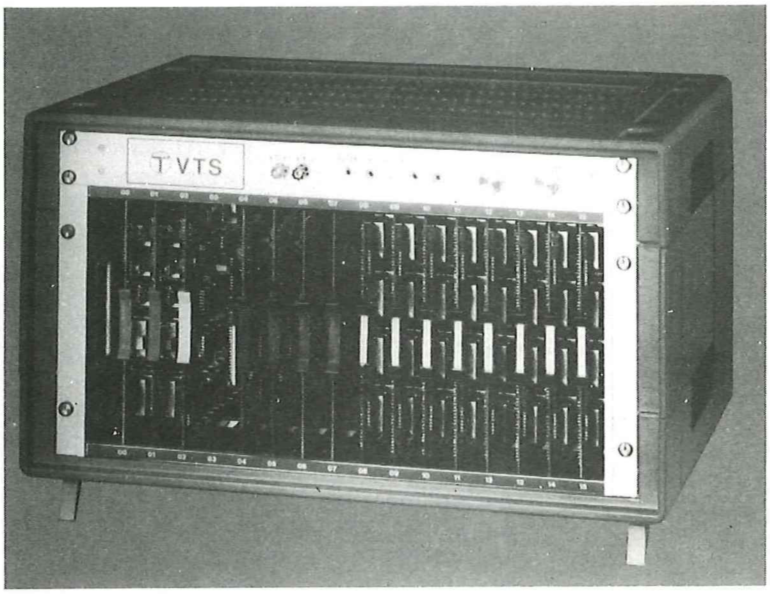

Figure 1
128-port VTS

† Switching Systems, British Telecom International Products

number of ports that can be controlled, although a practical limit is given by the memory storage of the computer and the number of available expansion slots in the computer chassis.

In general, the smaller, more portable systems are used in a repair or maintenance environment, and the larger systems for development, production and installation.

Wherever possible, CMOS technology is used to minimise power consumption. This allows smaller power units to be used with no forced cooling, and results in less than 500 W dissipation from a 1024-port system. Also, to minimise costs in what is essentially a low-volume system, no hybrids, programmable logic arrays (PLA) or other non-proprietary components are used. The computer is a standard IBM-PC® or compatible running MS-DOS® such as the Merlin M5000. It contains only one card peculiar to the VTS—a parallel bus controller. Peripherals such as printer and serial ports are optional, although their inclusion gives greater VTS flexibility.

VTS PRINCIPLE

A block diagram of the main elements of the VTS is shown in Figure 2. The principle of operation is that all ports (or a subset of ports) of a target system are connected to a relay-channel matrix. The number of relay channels corresponds to the maximum number of target ports which may be connected. Each relay channel is capable of connecting the 2-wire port to either (or both, if required) of two 2-wire test buses, or of connecting a 600 Ω resistive loop across the port.

The two test buses run throughout the VTS and, by using other cards, a variety of circuit elements may be connected to the test bus either to place conditions on the port or monitor from it.

The elements which may be connected to a relay channel include various tone detectors and receivers, loop-disconnect and multi-frequency (MF4) diallers, ring detectors, earth conditions, etc.

The relay matrix is realised with a number of 'relay tree' cards each capable of terminating sixteen 2-wire ports. Sixteen such cards can be mounted in a single 19 inch shelf, and up to 64 cards are controlled by a single parallel control bus from the computer. If the matrix is to be larger than 64 × 16 (that is, 1024 channels), then extra control buses may be used as required.

Other system cards fall into two categories. First, there are control cards which are common to any VTS whatever its configuration. These are station simulators, digit sender/receiver (DSR), and tones card. Secondly, there are various other cards which terminate or interface to specific peripherals. These include bulk trunk simulators (BTSs) for public switched telephone network (PSTN) circuit termination, signalling system

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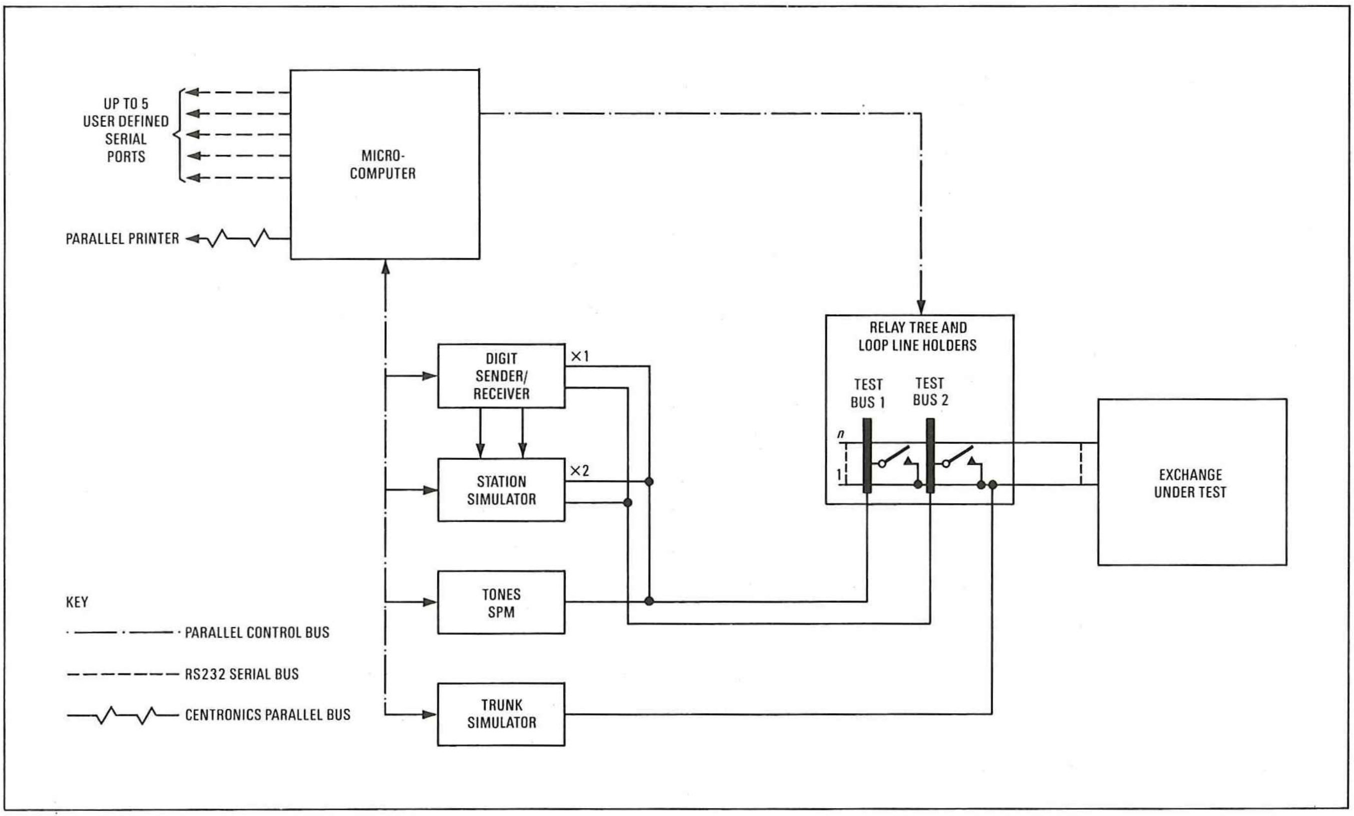


Figure 2
Block diagram of VTS

DC5 simulators, and other cards whose function is generally to facilitate testing of specific PABXs; for example, Monarch® console, Herald® terminal.

A total of 64 cards of any mix of these types are controlled by another parallel control bus.

The VTS controls testing by means of a configuration table which maps each external port to the relay matrix. As stated previously, it is not necessary to connect all ports of the target exchange to the VTS. A subset may be tested; examples of a subset may be all ports on one shelf, all first cards of all shelves, all odd ports, etc.

Alternatively, the VTS may be connected to several separate target systems simultaneously, either of the same type or different. This is particularly useful in a repair environment where circuitry from different exchanges is repaired, since cards may be inserted into one of several captive systems and a series of tests performed without the need for any hardware or interconnect changes.

HARDWARE

Control Bus

In a VTS having 1024 ports or less, there are two separate parallel control buses; one for the group of cards comprising the relay matrix, and one for all other cards. These are known respectively as the *relay group* and the *simulator group*.

The buses are identical except that the relay group has no input facility (all references to input/output (I/O) are with respect to the computer unless specified otherwise). Circuitry for control of both buses is contained on a single IBM-type card housed in one of the computer's expansion slots, and the card is connected to the VTS via two 50-way ribbon cables. Also included on the computer card is a millisecond timer which allows accurate delays to be measured for timeouts and other purposes.

A control bus has a 16 bit output, a 16 bit input, and handshake bits. An I/O bit defines whether the current command is an input or output code.

A typical sequence of events for an output command (to either relay or simulator group) might be:

Place 16 bit data on output bus
Set I/O to indicate output
Toggle strobe bit
Await handshake from cards

It is arranged that every card controlled by a bus must answer a command even if the command is not for that card. Only the required card will act, but all must respond.

Monarch® and Herald® are trademarks of British Telecommunications plc

A typical sequence for an input command (from simulator group only) is:

Place 16 bit data on output bus
Set I/O to indicate input
Toggle strobe bit
Await handshake and strobe in 16 bit input data

The 16 bit output bus of each control bus is defined so that the top six bits (DO15–10) contain the address of the card for which the command is destined. The remainder of the output bits (DO9–0) have variable functions depending on the card type. For example, for a relay card, bits DO9–6 define one of the sixteen channels on that card and bits DO5–0 define the command itself; for example, operate loop relay.

Handshaking should ideally be as fast as possible so as not to limit program execution. This is simple to arrange for non-intelligent cards (cards which do not have processors) since their response time is controlled by discrete logic chip delays. However, processor-driven cards have relatively long response times (of the order of several milliseconds).

This delay is unavoidable if the slow card is being addressed, but the protocol requires that all cards must respond to any command. To resolve this problem, it has been arranged that intelligent cards have a two-condition handshake circuit arrangement. If the card is being addressed, the response time is governed by the on-card software; if not, the processor is not interrupted and external discrete logic completes the handshake.

VTS cards have dual-in-line (DIL) switches to set the card address. This means that any card may be placed in any slot (with the proviso that relay and simulator cards are not mixed on the same control bus).

Backplanes

All backplanes are identical, whether for relay or simulator group cards, and provision is made for sixteen cards to be mounted in each backplane. The parallel control bus is common to all 16 slots. Similarly, the power rails, ringing current, and test buses are also distributed to each slot. All these signals are independent of the function of the cards and are fed to each card via a 96-way connector.

The card-dependent signals are connected to the cards via 32-way connectors from the backplane. These connections are usually the port wires, but can include any specific signal required by an individual card.

A ribbon cable terminated on the backplane carries power supplies, ringing current, and subscriber's private meter (SPM) voltage from the appropriate supplies, and a second ribbon connects the parallel control bus to the computer. Both ribbons can be daisy-chained over as many backplanes as necessary.

Station Simulator

Most VTS units contain two station simulator cards. Each card is hard-wired via soldered links to one of the two test buses and, with the exception of this link and the card address, the two cards are identical. Two cards are provided, rather than one card capable of switching between buses, because, in some situations, it is necessary to connect different elements to both test buses simultaneously. In addition, the station simulators are the most heavily used cards in the system. A block diagram of the card is shown in Figure 3.

The station simulator provides all facilities which would normally be associated with a PABX extension or a customer's telephone. These are:

(*a*) 600 Ω resistive loop,
(*b*) call progress tone detectors,
(*c*) ring current detector,
(*d*) provision of loop-disconnect and MF4 dialled digits, and
(*e*) earth either wire (for recall facility).

In addition, there is a high-impedance AC loop which is used to provide a loop during tone detection without degradation of the tone frequencies. There is a capability for up to three more undefined facilities to be hand-wired if a specific application demands.

The station simulator does not generate dialled digits, but accepts logic-level signals from the DSR card, converts them to line levels and transmits them. Nor does it provide a timed-break recall facility, since this is more easily achieved by using the 600 Ω holding loop of the relay matrix.

The call-progress tone detectors consist of five narrow-band detectors and one wideband cadence detector. The narrow-band circuits are tuned to 350 Hz, 400 Hz, 450 Hz, 1000 Hz, and 1400 Hz, these being constituent frequencies of standard tones in the UK network. The distinction between tones having the same frequencies, but different cadences, is achieved by reading the wideband detector output and differentiating in software. The detector bandwidths do not overlap, but are wide enough to enable detection of, for example, the 440 Hz constituent of UK dial tone with the 450 Hz detector.

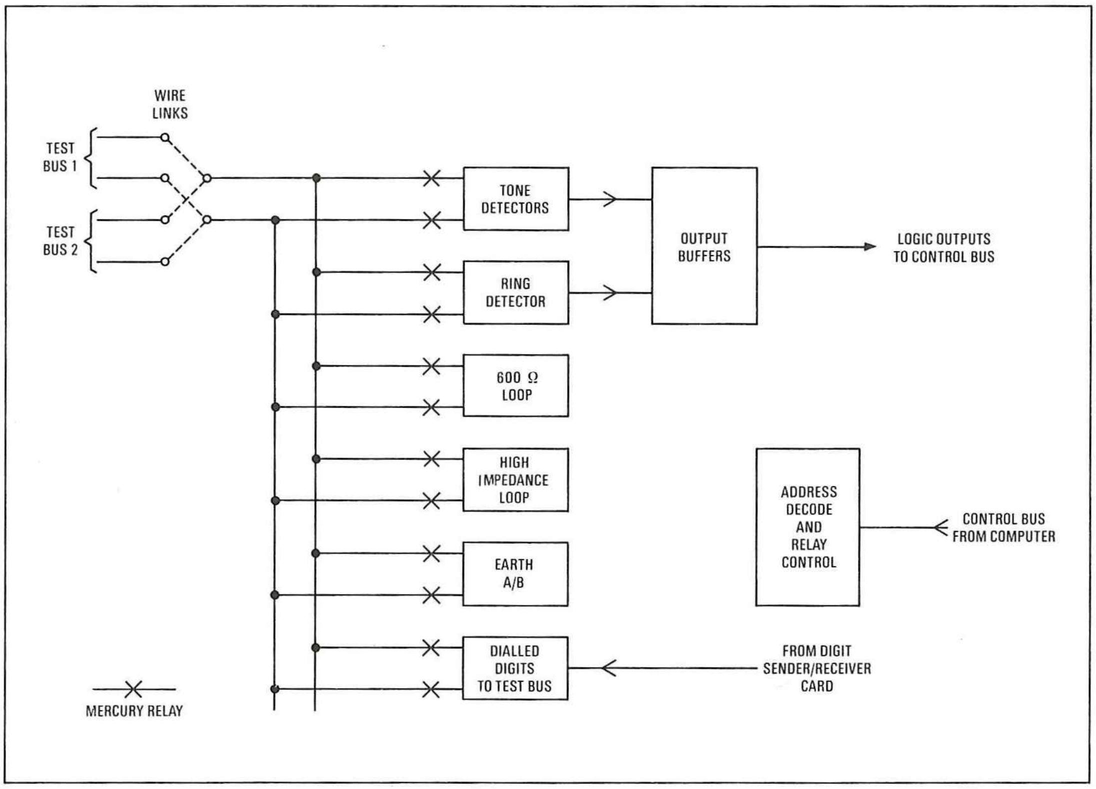
Where different tone frequencies are required, these can easily be set up by resistor changes. Cadence variations can be accounted for by simple software amendments.

Distinction between different ringing current types is carried out in computer software.

Digit Sender/Receiver

The DSR card provides dial pulse and MF4 digit generation, dial pulse and MF4 digit reception, and generation and detection of an 820 Hz continuity tone. All except digit generation can be achieved on either test bus (digit generation is output directly to the station simulators). Figure 4 shows a diagram of the main elements.

Figure 3
Station simulator



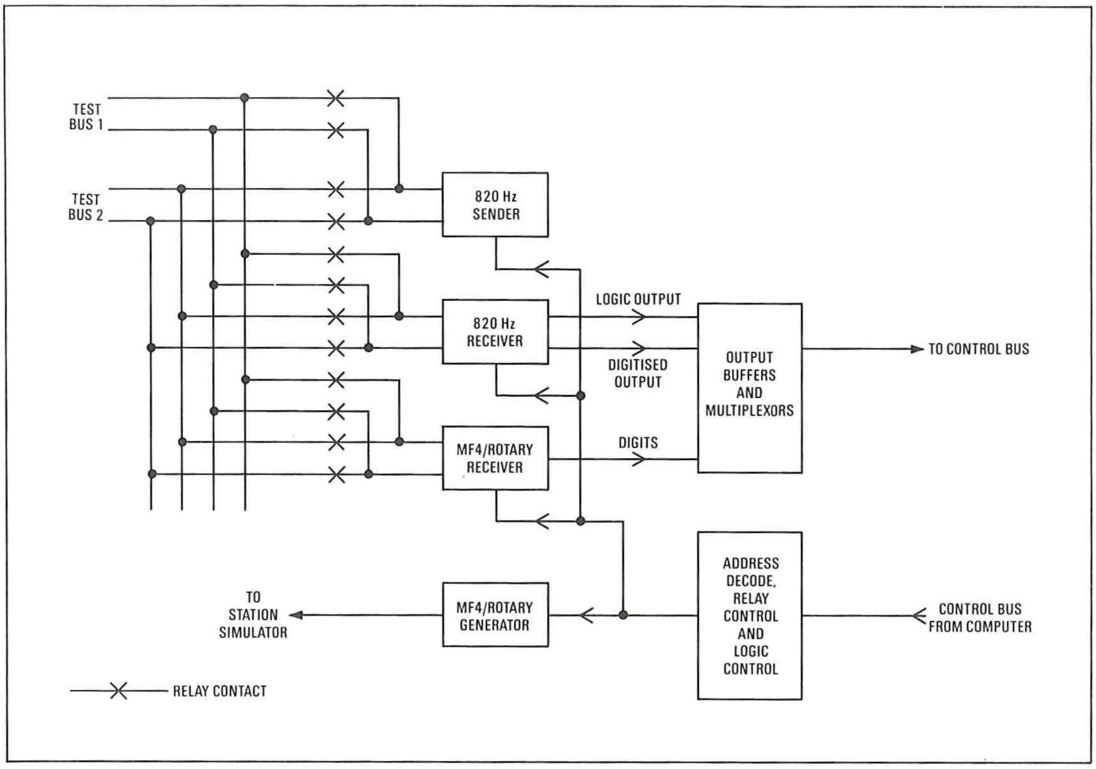


Figure 4
Digit sender/receiver card

Continuity tone detection consists of two parts. There is a simple GO/NO-GO indication of continuity tone presence, and an 8 bit digitised output of the tone level. Although the resolution of this is not enough for crosstalk measurement, it gives a good measure of such parameters as station-to-station loss up to about 30 dB.

On entry to the program, the DSR connects its continuity tone generator to the tone detector with a 600 Ω loop. The resulting tone level is noted and used as a 0 dB level, from which all subsequent level measurements are referenced.

Tones Card

The tones card is a multi-function unit which includes call-progress tone generators, an SPM facility, an audible alarm, and a test bus amplifier. Figure 5 illustrates these facilities.

Call-progress tone generators are provided primarily for use in self-diagnostics to check the performance of station-simulator tone detectors. A secondary use is to provide dial tone to trip dial-tone detectors which may be present in the target exchange. The tones may also be used for any purpose the user wishes during testing.

Tones are provided as eight separate sine waves of different frequency. Standard frequencies are 0 Hz (silence), spare, 350 Hz, 400 Hz, 450 Hz, 820 Hz, 1000 Hz, and 1400 Hz. If a user wants different frequencies, these may be easily set up at the expense of the existing ones.

Complex call-progress tones are derived by adding individual frequencies so that, for example, UK dial tone would comprise 350 Hz and 450 Hz.

Cadencing of tones is achieved in on-card software, and up to a total of 16 different call progress tones are available, one of which must be silence. As standard, the tones card has the following tones:

(*a*) silence,
(*b*) spare,
(*c*) 350 Hz,
(*d*) 400 Hz (UK number unobtainable),
(*e*) 450 Hz,
(*f*) 820 Hz,
(*g*) 1000 Hz,
(*h*) 1400 Hz,
(*i*) 350 Hz + 450 Hz (UK continuous dial tone),
(*j*) 350 Hz + 450 Hz (UK interrupted dial tone),
(*k*) 400 Hz + 450 Hz (UK continuous ring tone),
(*l*) 400 Hz + 450 Hz (UK standard cadence ring tone),
(*m*) 400 Hz + 450 Hz (UK inverted ring tone),
(*n*) 400 Hz (UK subscriber engaged tone),
(*o*) 400 Hz (UK equipment engaged tone), and
(*p*) spare.

Any cadence variations (for example, for tones required by other administrations) can

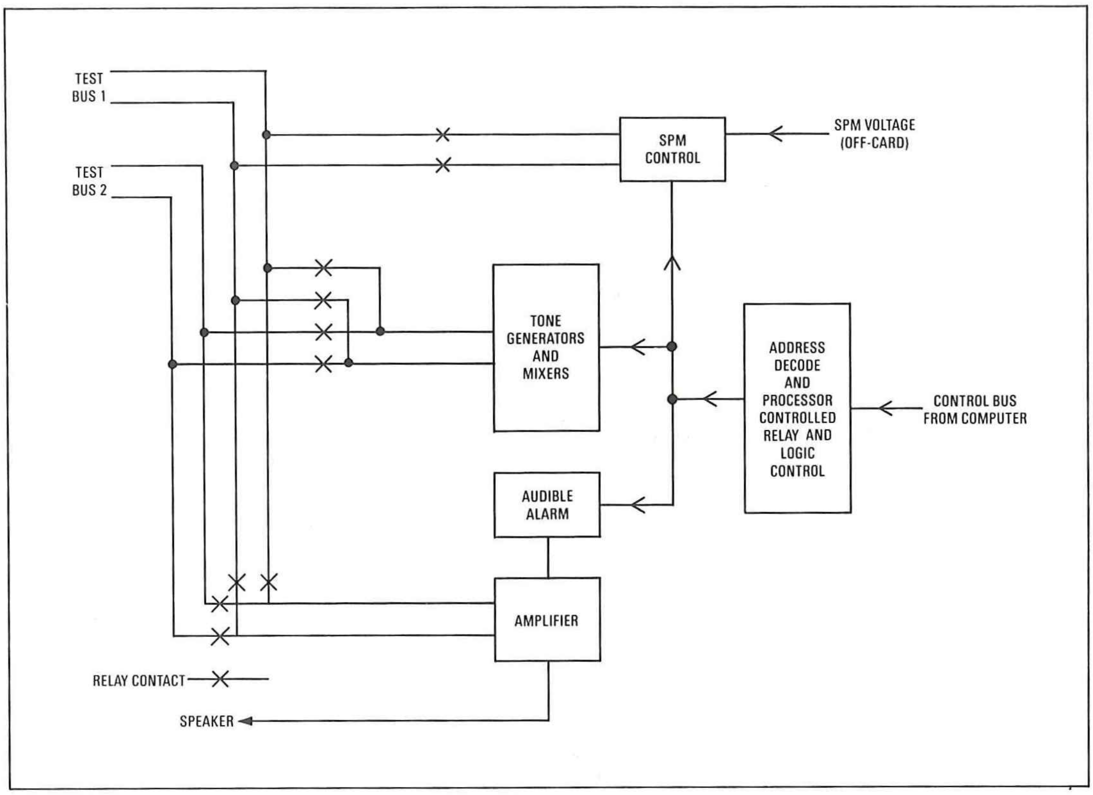


Figure 5
Tones Card

be easily achieved by altering the on-card software.

The SPM voltage is actually generated off-card since the required components are too bulky to incorporate on a standard card. The SPM voltage is fed to the tones card and, under computer control, SPM pulses of varying duration may be applied to any relay channel. There is also the software option of two different SPM voltage levels so that the user may test correct functioning at a specified preset minimum and maximum SPM level.

The alarm feature is useful in that, since VTS testing proceeds unsupervised, a failure may pass unnoticed. If required, the user can be alerted either on a failure, or on any other event. The alarm consists of several bursts of high-volume tone through the card amplifier. This method is preferable to sounding the computer 'bell' since it does not hold up execution of the test while the alarm is being sounded.

The test bus amplifier is a high-impedance amplifier which may be manually switched to either of the two test buses in order to monitor activity. The speaker is mounted off-card within the cabinet.

The above cards constitute the mainstay of the VTS. Other cards are available.

Bulk Trunk Simulator

The bulk trunk simulator terminates eight PSTN ports, providing correct idle conditions. Access to the ports from the test buses is achieved by connecting the ports to relay channels. The card has an on-board processor, and each port can be individually programmed to be earth- or loop-calling as well as auto-answering outgoing calls. Incoming calls (from the card to the target) involve a computer command which causes ringing current to be applied from the bulk trunk card. Port programming is achieved automatically by the computer by reference to the port's entry in the configuration table.

DC5 Card

The DC5 card terminates up to 16 DC5 signalling circuits. The earth and mark (E & M) wires terminate on the card and the speech pair is treated as a 2-wire extension and terminated on a relay channel.

Herald Terminal Simulator

The Herald terminal simulator is specific to the Herald PABX (or other targets which use the Herald protocol). A single simulator can terminate 16 Herald ports, providing key sending, and light-emitting diode (LED) reading. If the port is of the display terminal type, the display may also be read. The port data pair is connected to the simulator, and the speech pair to a relay channel.

Monarch Console Interface

The Monarch console interface is specific to the Monarch PABX (or its derivatives in other countries) and consists of two parts. An interface card is located in the VTS shelf, and

a small multiplexor unit is situated in place of the ribbon cable between the two halves of the console. By using the interface, console keycodes can be transmitted, and the console's LEDs and liquid crystal display (LCD) can be read by the computer.

Monarch Database Download

The VTS must know how a target exchange is mapped to the relay matrix. This data is held in a configuration file (detailed later). In maintenance and installation environments where configurations vary from site to site, it would be convenient if the configuration information could be downloaded directly from the target exchange. The download card does this for the Monarch PABX, creating a usable configuration in a fraction of the time which would be required to complete the task manually.

SOFTWARE

General

Software for the VTS falls into three categories:

(*a*) on-card software which is used in several processor-driven cards (for example, tones, bulk trunk, Herald),

(*b*) computer software not specific to the VTS (for example, compiler), and

(*c*) computer software specific to the VTS.

On-Card Software

Software for intelligent cards is usually written in assembler since the programs are generally small. The 8048/9 processor is commonly used because of its single-chip processor capabilities. Although more powerful single-chip processors are available, the 8048 is relatively inexpensive, simple, and proven interfaces for control and handshaking can be used on different card types and so minimises new card design.

For similar reasons, some other cards are presently controlled by 8085 processors rather than 16 bit chips, although this situation will probably change for new designs.

Non-VTS Computer Software

Non-VTS computer software includes items such as compilers, linkers, word processors, and operating systems.

The operating system is MS-DOS (or its variants on compatible computers). This is a necessity for all VTS computers, as is a word processor for the creation of configuration and command files (outlined later).

Compilers and linkers are necessary if users write their own test programs; this will especially be the case in a development environment. In situations where a VTS is used in a less variable environment, for example, repair workshops having captive target systems whose configuration does not alter, the VTS may be used to run a standard set of programs, obviating the need for compilers, etc.

VTS Software

All VTS programs are written in the 'C' high-level language. A library of unlinked object modules (called *tvs.lib*) is provided for the user. These modules provide telephonic functions such as 'offhook', 'dial', etc., as well as many lower-level features such as string manipulation and timers.

tvs.lib may be linked with a user's own test code to provide a customised executable program. The result is an executable program which is menu-driven and user-friendly. The test program itself is invoked as an option from one of the menus.

For those users who do not write their own code, a selection of standard multi-option menu-driven test programs is provided; new test programs are continually being written for different applications.

A test program may consist of from one to several thousand lines of source code which may call the *tvs.lib* functions in the required order. The resulting code is an English-like program, since the function names are chosen to reflect their uses. For example, a simple test program which takes all stations 'offhook', checks for dial tone and puts them 'onhook' might be as shown in Figure 6 below:

```
testproc()
{       int i;
        for (i=1; i<=maxlsn(); i++)
        {
        offhook ( i );
        dialtone( i );
        onhook ( i );
        }
}
```

Figure 6
Simple test program

A test program must always have an entry procedure called *testproc*, this being the entry point from the *tvs.lib* program. *maxlsn* is the highest numbered station in the configuration, and *i*++ is a 'C' shorthand for incrementing the variable *i*.

Routines to test more complicated facilities are easily written in a modular form, and the resulting test procedures are linked with *tvs.lib* to provide an executable file.

For users writing their own test programs, the sequence of events to create an executable file is as shown in Figure 7.

All high-level routines such as *offhook* and *onhook* return a value which indicates the success or failure of the attempted action. A value of zero is returned if successful, and a variety of non-zero codes indicate a mode of

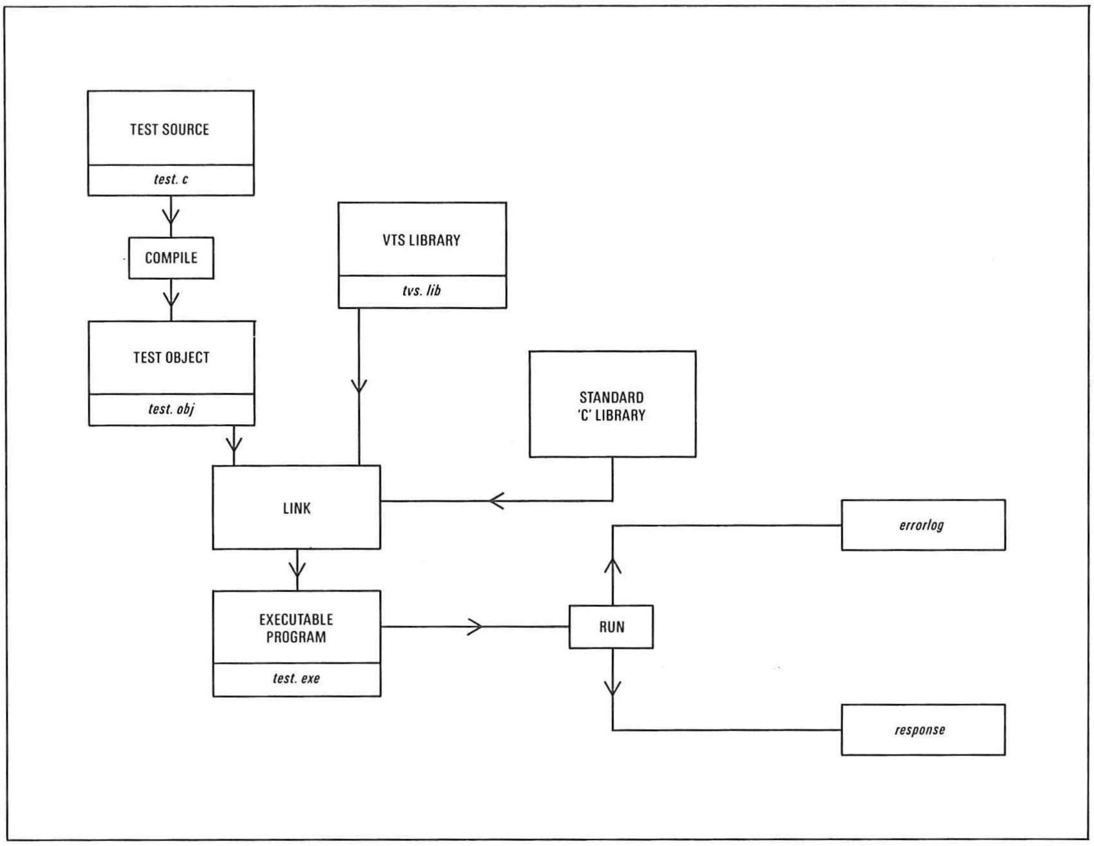


Figure 7
Creation of a VTS test program

failure. For example, for *dialtone*, return codes have the meanings shown below:

0 successful
1 specified logical station is illegal
2 specified logical station is onhook
3 no dial tone detected prior to timeout

Not only is the return code sent to the response output (see later), but it may be tested by the program to ensure that an early

Figure 8
Example program

```
testproc()
{               int i;
                for ( i = 1; i < maxlsn(); i++ )
                {
                    testcall( i );
                    dropall();
                }
}

testcall( i )
int i;
{               if ( offhook( i ) > 0 ) return;
                if ( dialtone( i ) > 0 ) return;
                if ( dial( i , lsndn(maxlsn())) > 0 ) return;
                if ( ringtone( i ) > 0 ) return;
                if ( offhook( maxlsn() ) > 0 ) return;
                if ( sscont( i , maxlsn() ) > 0 ) return;
}
```

test failure (for example, no dial tone) is not followed by error reports at every subsequent stage of the same call. Figure 8 shows a program which causes all stations (except the last) of a configuration to call the last station. At each stage, failure results in the cessation of that call.

Although this example may look more complicated than the first, the names of the called routines should enable the reader to follow the logic. For each station, the program calls *testcall*, which is part of the test procedure with a parameter *i* (the current station number). In *testcall*, various routines which set up the connection are called. If any routine fails, execution passes immediately back to the **for** loop, which releases all relays (*dropall*) and steps onto the next station.

Two other points in this example are the routine *sscont*, which causes a two-way transmission check between the specified stations, and the function *lsndn*, which returns the directory number of a specified station. It is therefore not necessary to specify a destination number explicitly, since the program will determine it.

Configuration Tables

In order to test a number of ports either in sequence or isolation, the VTS must know how its relay channels are mapped to the target system. This is achieved by means of a configuration table, held in the computer's memory, which relates each physical port to

a relay channel. Relevant information such as directory number and signalling type (for example, MF4, loop-disconnect dialling, etc.) is also entered.

Each target system port falls into one of three categories: logical station, trunk, or console, known to the VTS respectively by its logical station number (*lsn*), logical trunk number (*ltn*), or logical console number (*lcn*).

A list of logical numbers together with relevant data (directory number, trunk type, etc.) is entered into a file (the configuration file) prior to program execution. On entry into the program, the file is read and a configuration table is created in memory. Thereafter, each port is accessed by reference to its logical number.

Any configuration data may be altered or deleted inside the program, and the new configuration saved back to disc. This means that if several separate target systems differ only slightly in their configuration, then only one file need be created manually. Others may be semi-automatically created by editing the first and saving.

It is possible in some cases to create configuration tables automatically by accessing the target system database. A specific example of this is the Monarch PABX (and its derivatives including UXD5 public exchanges) where a purpose-designed VTS card extracts the complete database and builds the required tables. A similar exercise is possible with almost any (common-control) target system if the database is held in defined tables. It may be downloaded either via a special card or via an RS232 interface (although the speed of the latter will obviously have a bearing on the total download rate).

Output Files

A VTS has two important output files which hold details of errors and test progress. The first is *errorlog* which contains test failure data, and the second is *response* which holds standard messages whenever one of the high-level telephonic routines is called.

The destinations of both *errorlog* and *response* may be individually selected to be visual display unit, printer, file, or any combination. In addition, the response output may be sent to enabled *errorlog* destinations so that a combined output results. All records are time stamped and have prepended symbols to allow easy sorting of large output files.

Interpreter

In common with most other compiled languages, 'C' has the disadvantage that minor changes to the source code necessitate re-compiling and re-linking. This can become tedious if the change is intended to be temporary or is made for experimental purposes.

VTS software incorporates an interpreter facility which allows the user to enter commands from the keyboard in a manner similar to many versions of BASIC. Each command is processed after entry and several commands may be entered on one line so that they are interpreted in real time.

All the high-level telephonic routines are available from the interpreter as well as several 'C' equivalent function calls. The return codes from high-level routines, which indicate success or failure, are testable by using conditional **if** and **while** loops. Twenty-six character variables and 52 integer variables are available and enable such constructs as variable-controlled **while** loops and conditional statements to be used. Command strings may also be assigned to the character variables to permit shorthand entry of complex statements.

The commands may be entered from the keyboard or as a command file. In the latter case, a previously created file consisting of valid interpreter commands is read as if it were entered from the keyboard. This is particularly useful where the same events are to occur several times, perhaps with different starting conditions given by the variables. Nesting of command files may be achieved with a limit given by the computer's possible total number of open files.

As an example, consider a command file which takes ten stations offhook, checks for dial tone, and clears (as in the first example previously). This can be written as a one-line multi-statement command:

let *i*=1 **while**(*i*<11) *offhook*(*i*) *dialtone*(*i*) *onhook*(*i*) **let** *i*++

Although the reader may not be familiar with the syntax, the sequence of events should be self-evident.

A further example demonstrates a more complex sequence where each station calls the directory number of the next station, performing a continuity check on each call:

let *i*=1
while(*i*<11) *offhook*(*i*) *dialtone*(*i*) *dial*(*i*,*lsndn*(*i*+1))\
ring(*i*+1) *offhook*(*i*+1) *sscont*(*i*,*i*+1) **let** *i*++

Some points in this example may need explanation.

The extent of a **while** loop is the current line. The '\' (backslash) symbol is a line continuation so that the interpreter inputs the second and third lines as one. The first line is not part of the loop, so may be specified separately.

Also note that the program ensures that ringing current is present on the destination (by use of *ring*) before it goes *offhook*.

This example assumes at least 11 stations in the configuration since, when variable *i* is 10, the eleventh station will be the destination.

A configuration file (described previously) is actually a special case of a command file, so that the configuration input and the commands themselves can be contained within the same file.

When used correctly, the interpreter can be a powerful aid to rapid testing of a target system. To give maximum flexibility, the facility is available to specify a command file on the program's invocation command line. In this case, the command file will be input after system initialisation, but before menus are displayed, so that specific conditions can be set up before testing commences.

Other Software Features

Advantage has been taken of the modular menu-driven structure of the VTS's software to incorporate many user-programmable features. These include variation of loop-disconnect dialling parameters and the ability to change between earth and timed-break recall, as well as many others. The user can also define up to nine arbitrary types of ringing-current cadence which may be identified during testing.

Diagnostic testing has its own menus for self-tests of most VTS equipment at pre-determined periods, prior to tests or during tests at the user's discretion.

The software caters for up to five serial RS232 ports so that the user can connect various devices simultaneously. An example of this might be a situation where the user has a serial printer, a target system with two man–machine interface (MMI) ports, and a modem on a fourth port; the modem could allow data (for example, *errorlog* records) to be dumped at remote points. The spare port can control a test call sender to provide background traffic.

Since the computer is a proprietary model with no modification (apart from the parallel control card), it is possible to add any of the variety of IBM-type cards which are commercially available to enhance the system. For example, a useful addition for transmission testing might be a IEEE-488 (HP-IB) interface to enable many items of test equipment to be controlled by the computer. Similarly, interfaces to other computers giving access to mainframes, networking and remote control could be installed. The number of possibilities is limited only by the user's imagination.

OTHER VTS APPLICATIONS

VTS Multiple-Call Card

Since a VTS has only one DSR card which generates MF4 and loop-disconnect dialling digits, it is not possible for the VTS in its usual form to generate more than one call truly simultaneously (although one at a time may be originated, then held indefinitely while others are generated). However, an approximation to this can be made if it is accepted that most common-control exchanges can process only one call at a time. That is, the control scans ports and accepts simultaneous digits as being interleaved from various ports.

VTS programs have been written which interleave digits from different ports to give a pseudo-simultaneous effect. This is only effective with MF4 sending and is (as with true simultaneous sending) limited by the number of target MF4 receivers provided.

Another method of providing simultaneous sending is to provide a second DSR card. This method entails writing extra subroutines to control the extra card, but it is effective.

Both these methods are useful for investigating the effects of traffic loading while the VTS is testing those ports carrying the traffic, but they suffer from the disadvantage that, while the computer is involved in controlling continuous sending, it cannot also easily check facilities on other ports.

This problem can be overcome by using a true test call sender to generate background traffic during facility testing. The disadvantages here are firstly that the test call sender chosen may not be controllable from the VTS computer so that any test call results are not directly correlated with VTS results, and secondly, proprietary test call senders are very expensive and inflexible. (Inflexibility here does not mean that the sender cannot be programmed with called number, etc; rather that if port A is connected to call port B, then port B cannot call port C or even port A without altering the physical connections.)

A VTS multiple-call card (MCC) has been developed which solves these problems, and gives great flexibility at a reasonable cost. An MCC card has eight ports controlled by an on-card processor. Each port has its own sending and receiving capability complete with tone and ring detectors. Any port may call any other port, not only on the same card, but also on any other MCC card in the system. Moreover, each port is completely bi-directional and this allows any pattern of calls across the system to be made and the effects of blocking to be assessed as well as purely unidirectional, unblocked patterns.

Future versions of the MCC are envisaged in which calls to test numbers external to the target will be possible, as well as the facility to program an Erlang traffic figure so that the processor will distribute calls about mean times to achieve a true traffic model. An MCC can be used either as a background traffic generator during VTS testing, with all control being from the VTS computer, or as a stand-alone test call sender. In the latter case, it can also be controlled from a teletype (or other RS232 device) via a serial–parallel card.

Serial–Parallel Card

The serial–parallel card converts a serial (RS232) input from a teletype or similar to the parallel format required by VTS cards (specifically the MCC). Since the bus control of all VTS cards is identical, it follows that it

is possible to control a VTS from a teletype fitted with a serial–parallel card.

Although menu-driven testing using a teletype is not practical, and the test programs will be less flexible, investigations into this aspect have been started, since it is likely that many users in an on-site environment may not require so much flexibility, and may find the transport of a relatively bulky computer an embarrassment.

Line Monitor

The VTS line monitor card has been designed for a specific application at the request of a VTS user. Its description is useful, not so much for the card itself, but for the fact that it demonstrates the flexibility of the VTS in fulfilling a function which had not previously been considered.

The problem was to investigate ring-tone no-reply reports on incoming PABX lines. Often these reports entail one or more engineers being on-site for perhaps three days, during which time attempts are made to identify lines which are ringing for more than a specified period; identification is often a manual task involving connecting neon lamps across the lines and watching them.

Usually, the eventual result is that the engineer knows that no technical problem exists (other than perhaps a shortage of operating staff), but the on-site communications manager must be convinced of this or further complaints will arise.

The solution was to design a card which monitored 16 lines continuously; the VTS computer scans up to six such cards, providing a static display of the status of all ports. If any line is ringing for more than a specified period, a printout results on subsequent clears or answers. Also, at any time or at the end of the test, a printout of total calls, average time to answer, etc. is obtained.

The use of this card provides hard evidence to customers of a possible need to revise their resources, and cuts engineering on-site time by about 50% compared with previous methods.

CONCLUSION

The VTS was originally intended as a development aid during design of the IT440 PABX. It was successful in this respect, because it helped towards the success of this system, especially in terms of its reliability.

Since the launch of IT440, the VTS has been developed so that it can be used for a variety of applications in many environments. Continuing development will doubtless ensure that it can fulfil other uses equally well.

The VTS is now used by departments within BT (including UXD5 development and repair and installation workshops) and by other PABX suppliers and manufacturers.

Biography

Paul Warren joined BT as an apprentice in 1966. After a period on subscriber's apparatus and exchange maintenance, he obtained a degree from Loughborough University of Technology and transferred to Service Department where he developed computer programs for exchange and signalling system fault analysis. He joined the Monarch PABX development group in 1980, with emphasis on the Monarch operator's console. Since 1984, he has developed the VTS from its original Monarch-oriented concept to its present form.

On-Demand Interactive Video on the British Telecom Switched-Star Cable-Television Network

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UDC 621.397.413 : 621.315.2 : 681.015

The British Telecom switched-star cable-television network, with its large and expandable bandwidth and sophisticated interactive control, offers the possibility of individual customer access to a video library facility. With this facility, customers will be able to access and control a large catalogue of entertainment and instructional programmes through their keypads. This article outlines the video library facility and its development to the pilot service at present being installed in Westminster, and is based on a paper which first appeared in British Telecom Technology Journal.*

INTRODUCTION

British Telecom (BT) has been actively preparing for the introduction of new cable-television (cable-TV) networks since 1981. A dual approach has been adopted: one aspect has been the development of coaxial tree-and-branch networks, drawing on the equipment and systems that have been developed in North America; the other is the development of an advanced switched-star network (SSN) offering cable-TV and related services. This has an open-ended capability to expand in scale, and diversify in range[1].

One of the advanced services possible on the switched-star network, with its large and expandable bandwidth and sophisticated interactive control, is individual customer access to a video library facility. Customers will be able to access a large catalogue of entertainment and instructional programmes and control their viewing through the controls on their keypads. It will be a premium service for which an extra charge will be levied, comparable with that made for the hire of a video tape, but within that restriction it will offer customers a radical alternative to their viewing options. They will be able to break out from the stream of pre-scheduled programmes and choose to view what they wish when they wish.

The video library, however, will not just be an on-demand film service; it will be able to support a wide range of interactive video services—a field of very active innovation[2]. The network allows for many customers to share a common interactive video centre. This offers many opportunities for new and attractive services which few customers will be able to afford to own personally. The range of programmes the library can support includes:

(*a*) films and documentaries,
(*b*) pop videos,
(*c*) video encyclopaediae,
(*d*) do-it-yourself (DIY) instructional material,
(*e*) interactive educational videos (programmed learning), and
(*f*) home shopping catalogues, including active demonstrations.

One library is designed to serve up to 250 simultaneous sessions, and it is estimated that this should be adequate for a sector of the cable-TV network with between 10 000–20 000 customers connected.

OVERALL REQUIREMENTS OF THE LIBRARY SERVICE

The video library service is novel in that it allows users to schedule their own viewing from a cable-TV network instead of being tied to the schedules of broadcast and pay channels. The service therefore was required to allow users to request a programme via their keypads at any time, and to aquire access to that programme within a short period (typically a few tens of seconds).

There was much experimentation, mostly on paper, in providing semi-scheduled services for popular films whereby users, on requesting such an item, would be allocated to the next showing of the film; there might be a new showing starting every 15 minutes or so. But the more this was investigated, the more it was realised that little was saved in terms of video channels required or video library hardware. Because of the user interface problems raised, the idea was shelved.

The decision was made that a copy of the programme accessed by the user is made available solely to that user for the duration of the session. No other user can watch that session, even passively. If other users want to access the same programme at a similar time, they are allocated a different copy of the programme and a different set of video playing hardware.

Once a user has finished a session, the video

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* KERR, G. W. On-demand interactive video services on the British Telecom switched-star cable-TV network. *Br. Telecom Technol. J.*, Oct. 1986, **4**(4), p. 41.

playing hardware, the copy of the programme and the video channel become available for another user; therefore, the cost is spread over all potential users, yet the programmes are potentially available to all users at all times. This means that, for example, a special educational programme (say from an organisation like the Open University) could be made immediately available to all customers by installing multiple copies in the video library; no extra hardware above that already provided for connection to the network would be required in any customer's home.

Because the library service was liable to be available to relatively small numbers of customers at the start, it was decided to make use of as much as possible of the consumer Laservision catalogue for items for the library. This catalogue is continuing to grow and contains at present approximately 700 items, roughly half of which are feature films, the rest being pop videos, opera, ballet, sport, children's programmes, humour and general interest. The video playing system (called *video source*) was required to provide a sensible and friendly standard user interface for all the standard videodiscs.

From early on in the development, however, it was also recognised that custom programmes might be attractive for video library users, and if existing programmes could be incorporated with little extra development, the way would be open for various programme makers to find an additional market for their wares on the video library. Because of the lack of standards, most custom interactive video programmes require a particular set of hardware (microcomputer, videodisc player etc.) and software, and so have to be considered as special cases. The library was required to allow incorporation of these programmes (including their own hardware) with minimal extra work, no changes to the software in the computer controlling the library (the library server), and minimal operator intervention.

In spite of these requirements, the target cost to a customer of an average 1·5 hours film (all in) was to be not much greater than the cost of renting it for a night from a videotape hire shop.

MARKET POTENTIAL

A market analysis was undertaken in early-1983 for network dimensioning purposes. The information given below is mostly taken from this analysis. Other more recent sources confirm much of the information[3,4].

Competing Services

Although the video library offers a unique and attractive way of viewing material, it will nevertheless have to compete with other means whereby the customer can view the same material, see Table 1.

According to the report, an average of 2·5 hours of pre-recorded material is watched per week by households owning video cassette recorders (VCRs).

Possible Traffic Levels

The expected traffic levels were also investigated. It was found that approximately 2·5% of a total week's traffic occurred on Sunday afternoon between 3pm and 4pm. Another busy period was Saturday evening between 10pm and midnight. In general, though, the viewing pattern was well spread and reasonable equipment utilisation could be expected.

The design of the video library was based on the traffic levels predicted by the analysis, and allows for up to 250 simultaneous sessions for between 10 000 and 20 000 customers connected to the switched-star network and able to access the library.

REQUIREMENTS OF LIBRARY DESIGN

The design requirements changed considerably during the conception stage. Early in 1982, the requirement was for a simple technology trial of a small network of 10 000 customers. By mid-1983, the BT SSN was to be a fully commercial system for deployment in areas of roughly 100 000 homes passed, with library service to cover all customers.

TABLE 1

Competing Video Services

Service	Cost	Derived* Cost/Film	Availability	Initiation Type
Broadcast TV	–	–	Very high	Scheduled
Pay-TV channels	£8–£12/month	£1·00	Cabled areas	Scheduled
Cinema	£1·50 each	£3·00	Towns	Scheduled
VCR tape hire	£15/month equipment £1·50/night tape	£1·50	10% all households 1982 ≈40% households 1986†	On-demand
VCR/VDP own media†	£15/month equipment	‡	As for VCR above	On-demand

Notes: * Derived cost assumes two people watching together
† added information over and above that in the report
‡ once purchased, a tape/disc can be seen for no extra cost

The plan now is for a pilot library system to pass roughly 10 000 homes in the Westminster franchise, with the potential for expansion to as many full-sized libraries as might be required for the whole area if market experience shows this to be a sensible option.

At the stage when the numbers looked very large, the decision was made to design a system which was radical, flexible and modular, and to ensure that the library could accommodate a range of disc players and not be tied to any one manufacturer or format.

It was essential for the customer to be unaware of different suppliers' equipment and to see as near as possible the same responses to keystrokes. This proved quite a problem, as in 1983 there were three incompatible videodisc formats[5,6]:

(*a*) Laservision (optical read reflective disc—Philips/Sony standard[7]),

(*b*) VHD (non-grooved capacitive-read disc—JVC standard, marketed in the UK by Thorn-EMI[8–10]), and

(*c*) CED (grooved capacitive-read disc—RCA standard, players manufactured for and marketed in the UK by Hitachi[11–13]).

Fortunately, the decision then to start with Laservision and to consider VHD and CED only when necessary has proved prudent: in the UK the CED format has died completely and the VHD format has no offering on the standard consumer market, being used only for custom programmes at the moment.

The design process resulted in a pilot library capable of handling up to 1000 titles (initially from the consumer Laservision catalogue), on-demand access, able to serve the expected traffic from 30 wideband switch points (WSPs), able to be expanded easily without further development, and able to be replicated elsewhere in the network to provide further service when required.

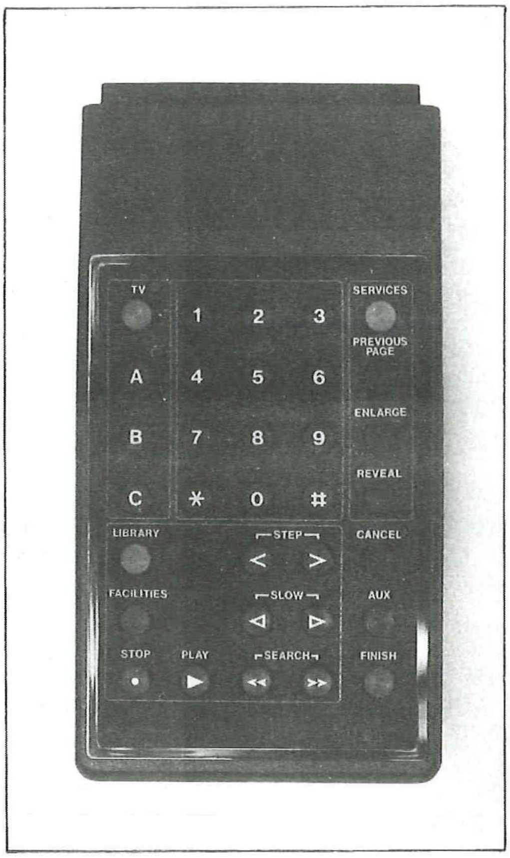


Figure 1
Hand-held infra-red keypad

USER OVERVIEW

Figure 1 shows the hand-held infra-red keypad by which the customer interacts with the system.

A customer asks for library service by pressing the LIBRARY key. The relevant WSP then allocates one of the on-demand video channels to the customer, informs the library computer of the channel identity, switches the channel through to the customer and then passes control over to the library computer. The customer then enters into a text dialogue to request a programme and to exchange password information. The library computer switches the allocated video source to the allocated video channel and the customer's programme begins. Customer keystrokes are directed through the WSP and network control system to the library computer, which directs them to the appropriate video source.

Once a session has started, customers use the keys on their keypad to control the viewing. For standard catalogue programmes, like films, that control can be simply stopping the programme, going over a part of the programme again, or skipping over another part. For more sophisticated items, the customer may wish to learn interactively from a DIY 'How to' programme, or study something from a video encyclopaedia: the level of control the customer is offered in these programmes is fixed by the programme creator, not the video library itself.

To end the session, the customer presses the FINISH key. This action is detected by the WSP which instructs the library to clear the session down. Alternatively, if the library detects the logical end of a programme, this is signalled to the WSP, and the session is cleared down. Charging is performed by the library computer on a basis of a charge for accessing the programme plus a charge related to the time spent viewing the programme; billing packets, which include a credit for the programme rights owner, are sent to the system administration computer[1].

TECHNICAL OVERVIEW

Interface of Library to Switched-Star Network

The library at the head-end or hub site[1]is a separate equipment module on the SSN, but coupled to the control and transmission

systems to present an integrated service package. It can thus be added to a SSN at a later date, or a small library system can be expanded.

All the control signals to and from the library are carried on one RS232 (19·2 kbit/s) link, which connects to a message concentrator[1] at the head end of the network. At the library end, this link is connected to a small 16 bit computer (at present a Micro-PDP11/23) which administers the whole library and the user sessions. This control interface to the library is rigidly defined within the project documentation scheme in terms of transport, flow and message-level specifications.

The outgoing video and audio channels are presented as PAL-I composite signals to optical fibre equipment for transmission to the desired WSPs, via hub sites[1] as required.

Structure of the Library

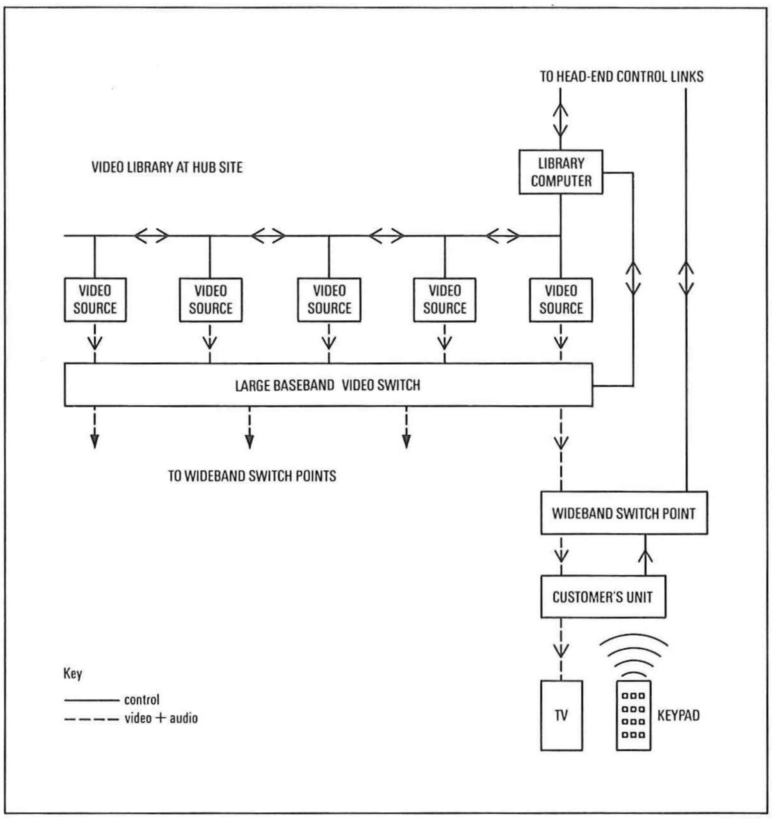
The library is administered by one small computer which interfaces to the rest of the SSN via an RS232 link as mentioned above, and to the rest of the library via a custom parallel control bus. This computer is called the *video library server* (VLS). Figure 2 shows a block diagram of the library.

Before the library structure was finalised, five research and development studies were let: one to a small UK firm with experience in audiodisc handling, and the other four to major consultants in the fields of robotics, flexible manufacturing systems (FMS) and automated production lines. The aim of the studies was to ascertain the optimum structure for the library, given the constraints of single videodisc player/single disc side at a time, large number of discs (of low media cost), number of players to be at least equal to the maximum number of simultaneous sessions desired (players being a relatively high-cost item), video switch (high-cost, depending on number of cross-points required), low accommodation for the whole using 2 m maximum height equipment, high availability of service in the event of a fault, unmanned service in general. The results of the studies were varied, but can be summed up as follows:

(*a*) the use of robots would be expensive and be a reliability hazard; and

(*b*) a series of videodisc players, with a mechanical means to load/unload discs from a central store, coupled with a large non-blocking switch, provided the most robust and viable structure.

Most of the proposals were based on rigid high-speed XYZ disc handlers serving large banks of videodisc players. Costings were surprisingly varied, but the most realistic looked expensive. The only exception to this was a very modular approach, based on existing technology and experience. This latter proposal was accepted on the grounds of modularity, flexibility, known technology, potential reliability and cost.



Note: disc handling, log-on caption generator and title specific menu generator are not shown

Figure 2
Structure of video library

The structure of individual video sources was modified to take into account the disc handlers, which allow a fixed number of disc players access to one unique pool of discs. This collection of video sources is called a *video source group*. The concept is important for the administration software to be able to identify which copies of programmes are able to be loaded onto which video sources. Automatic disc handlers are not, at present, to be used for custom sources, as these tend to have custom hardware/software structures, although there is no reason, in theory at least, why they should not be.

The compact design of the automatic disc handlers allows three units to be mounted in just over a 2X2X2 metre cube, with maintenance access only required from one side. This enables units to be installed side-by-side and back-to-back, thereby using floor space very effectively. Figure 3 shows one layer of a prototype disc handler similar to the production handlers installed at the Westminster head end.

The switch is a baseband analogue 3-level matrix, arranged as modules of 16:32, 32:32, 32:16 matrices in shelves, along with the required signal buffering and low-level control cards. The analogue signal to be switched is specified to be PAL-I, that is, baseband video with monoaural analogue audio at approxi-

mately 6 MHz, with the capability of switching composite PAL with stereo sound as being proposed by the BBC for terrestrial broadcasts.

The control bus used to interconnect the VLS computer with the video sources, video switch and log-on caption generators, was an internal development to meet the special requirements of the system:

(*a*) low cost,
(*b*) ability to work over lengths of 100 m or so,
(*c*) VLS computer to act as master,
(*d*) low central processor unit (CPU) overhead on VLS,
(*e*) very low software and CPU overhead on slave units,
(*f*) assymmetric data flow, half-duplex, message based,
(*g*) support bursts of roughly tens of kilobyte/second in either direction,
(*h*) auto slave reset via bus,
(*i*) capability of polling slaves without requiring action by slave CPU, and
(*j*) reasonable fault detection, error handling and recovery, via timeouts.

The result was a parallel bus based on multi-core ribbon cable.

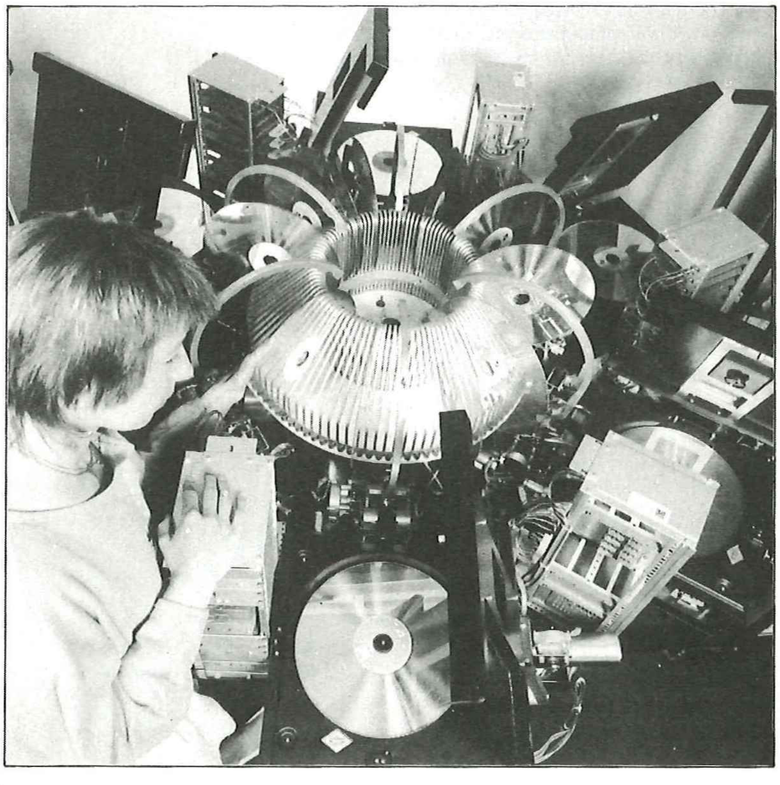
FACILITIES OFFERED

Standard Video Source

The SSN keypad has keys dedicated to the library service:

LIBRARY—to enter the service,
PLAY, STOP, <STEP>, <SLOW>, <<SEARCH>>—simple control of programme,
FACILITIES—to go to a menu of options.

Figure 3
Prototype disc handler



The standard video source comprises a teletext-grade caption generator, two small microcomputers and a videodisc player, and implements the above keystrokes as the Laservision discs allow. Constant linear velocity (CLV) discs, which are used mostly for films, do not allow step frame or slow motion, so when these keys are pressed by a user, a one-line caption is overlayed for a few seconds on the video. The STOP function with CLV discs is implemented by pausing the player and displaying the caption 'Paused' to the user.

The facilities menu opens up other options, including:

(*a*) change current disc side (if programme occupies more than one disc side),
(*b*) random access to a required frame number (CAV discs) or timecode (CLV discs),
(*c*) random access to a required chapter (if disc has chapters on it),
(*d*) displaying or clearing an index of current frame number or timecode and chapter number (if available) on top of the video from the player,
(*e*) changing audio status—either the left or right or both channels can be sent to the user, and
(*f*) simple title-specific menus (optional).

The last option, title-specific menus, allows the user to get away from Laservision technology-dependent concepts such as frame number, timecode, disc side or chapter number and instead go to a point in the programme by choosing the content of that part from a simple list. For example, if the videodisc *British Garden Birds* were on the library, the title-specific menu would probably offer menus of particular birds, whilst a tennis training programme would offer menus of particular strokes of the game to learn about, and so on. This information is downloaded over a separate data communications link to the video source at the same time as the disc is being loaded into the player and being spun up to speed at the start of the session.

A user finishes the session either by pressing the FINISH key on the keypad, or by being forced off when the video source detects that the programme has ended.

Custom Video Source

Once control is passed to any video source, the source can react to all possible one-byte keystrokes as it pleases. No restrictions are placed on this, except the code corresponding to the FINISH key, which is filtered out before it is passed to the video source and forces the session to abort. The standard video source merely has a fixed reaction to all keystrokes

under all conditions, suited to playing standard consumer discs from the catalogue.

A custom video source could be anything from a simple linear programme to a sophisticated interactive video learning package, driven by a local personal computer, or even coupled via a local microcomputer to a remote computer, providing the output signal is composite PAL-I video and audio, and the control keystrokes can be entered over the network from the user's SSN keypad or a compatible alphanumeric keyboard.

A number of custom video sources are being looked at, including one offering advanced moving-video home shopping, another offering video mapping and others from the education and training fields.

CONCLUDING REMARKS

Interactive video is a field of rapid innovation which will increasingly enter public awareness over the next few years. The BBC Domesday project, which is creating a new Domesday Book on two interactive videodiscs, is one such development which will have a high public profile since it is expected that many schools will acquire videodisc players and control computers, but it is only one among many that will appear. The BT video library service is capable of allowing customers to access many of these interactive programmes on a standard TV set; it will thus allow BT to explore and assess the public desire for remote on-demand access to large central stores of programmes.

The pilot version of the library is due to start trial service in early-1987 with payment-based service later in the year.

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Biography

Gordon Kerr graduated from Cambridge University in 1975 and joined British Telecom Research Laboratories. He began work in a group responsible for the design and development of a full-duplex 9600 bit/s data modem for the switched network. In 1981, he founded a new group responsible for defining, designing and developing an on-demand interactive video service for the BT switched-star network development project. In January 1987, he became responsible for the section developing visual service terminals.

Remote Access System for TXE2 Exchanges

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UDC 621.395.345 : 621.395.664

TXE2 exchanges have been providing customers with good service for some 15 years at more than 1600 sites thoughout the UK. These exchanges (many of which have only a few hundred lines) tend to be in relatively remote geographical locations. This has resulted in increased travelling costs as the number of maintenance staff has been progressively reduced. This article describes a system designed by the authors which allows certain customer provision work to be carried out remotely from the TXE2 exchange.

INTRODUCTION

The following article describes a remote access system (RAS) designed by the authors that allows a number of facilities to be implemented on customers' lines that are connected to all types of TXE2 exchanges. Access to an exchange can be from one or several remote points. The facilities available are

temporary out of service (TOS),
outgoing calls barred (OCB), and
incoming calls barred (ICB).

The above facilities may be invoked on any directory number (DN) working on the exchange, including hypothetical DNs.

The system enables maintenance visits to exchanges for TOS work arising from non-payment of bills to be reduced. Most of the visits arise not from the initial TOS work, but from the subsequent restorations of service. As they are usually spaced out over a period of time, each restoration normally requires a separate visit to the exchange.

The versatility of the system can also be used to speed up circuit provision (CP) work, in the following way. If some, or all, of the free DNs available in the exchange are threaded, that is, made working, and then made TOS in the RAS, it is possible to provide an exchange line without a visit. This presupposes that the main distribution frame (MDF) can also be prejumpered, with DNs being allocated to distribution points (DPs). Meter readings can also be taken at the time of pre-allocation.

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SYSTEM DESCRIPTION

The RAS (see Figure 1) comprises

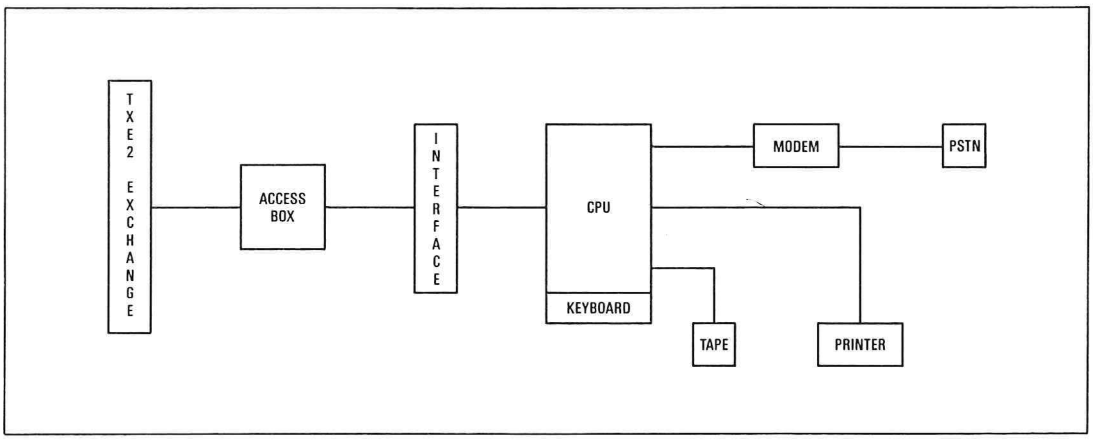
(*a*) an interface,
(*b*) a central processing unit (CPU) board,
(*c*) a pulse amplifier,
(*d*) a modem,
(*e*) a cassette tape, and
(*f*) a printer.

Each of the functional circuit blocks of the RAS is now described.

Interface

The interface monitors the exchange primary decoder, and hence has the last four digits of the DN in the form of thousands, hundreds, tens and units. This number is the DN of the calling, or called party, being processed by the exchange at any point in time. (It should be noted that TXE2 exchanges can process

Figure 1
Block diagram of remote access system



only one call at a time.)

The interface performs level changing and code conversion from the two-out-of-five-code used in the exchange hardware to the binary coded decimal (BCD) used by the CPU. The interface also provides isolation between the TXE2 and the CPU in the form of opto-isolators. Parity checking is carried out at this stage. Only if the correct parity is seen by the interface on all four sets of two-out-of-five-highways is an interrupt sent to the CPU to indicate that a call is being processed by the exchange.

The DN information is now in the form of transistor-transistor logic (TTL) levels and coded in BCD; this information is presented to the CPU board, as shown in Figure 2.

Interface Circuit Detail

The two sides of the TXE2 exchange are isolated by diodes; the two-out-of-five code is presented on five leads for the thousands digit, and a similar set of five leads for the remaining hundreds, tens and units digits.

These input conditions are level changed by opto-isolators, and then multiplexed into a code-convertor circuit. The multiplexer allows only two code-conversion circuits to be used to convert four sets of data; that is, thousands, hundreds, tens and units.

The decoded thousands and hundreds information (in BCD) is now made available to the 8 bit parallel input port of the CPU, whilst parity checker integrated circuits (ICs) on all four sets of two-out-of-five inputs generate an interrupt request to the CPU. This interrupt activates the service routine of the CPU which then reads into random-access memory (RAM) the thousands/hundreds data. Once this read has been accomplished, the CPU returns a handshake signal to the interface; this results in the multiplexers switching through the tens/units data in the same way.

The CPU loads the tens/units data into RAM and can then carry out a fast search through the number table for comparison. If an identical number is found, then outputs from the two least significant bits (LSBs) of the top portion of the parallel input/output port (PIO) are taken through more opto-isolators back into the exchange to drive the pulse amplifier circuits.

The self-test facility is also contained in the interface hardware and functions in the following way.

The TXE2 exchange has, as part of its normal operation, a self check which involves initiating a call from one or more DNs every six minutes. These DNs are service numbers and are always made ICB.

A unique condition is taken from the test call relay-set into the interface unit, and the test number DNs are made ICB in the RAS in the normal way.

When this test call is initiated, a test is made and the unique condition from the test relay-set starts a timer in the interface unit. This timer, if allowed to mature, raises an alarm. However, the timer should always be reset by an ICB condition coming back from the RAS central processor, since the test DNs exist in the number table as ICB.

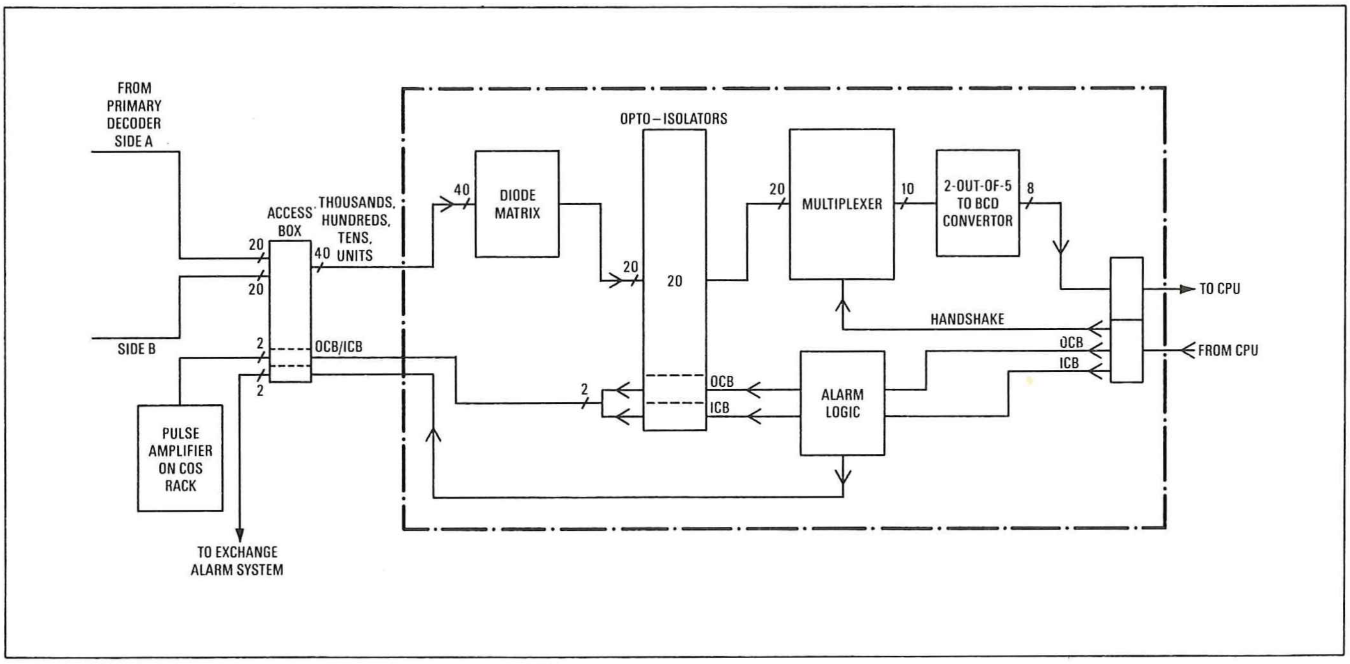
This self check proves

(*a*) that the highways between the primary decoder and the RAS are intact,

(*b*) that the interface is able to correctly decode to BCD and handshake with the CPU, and

(*c*) that the CPU is running in program and that the number table exists and is not corrupted.

Figure 2
Interface unit



CPU Board

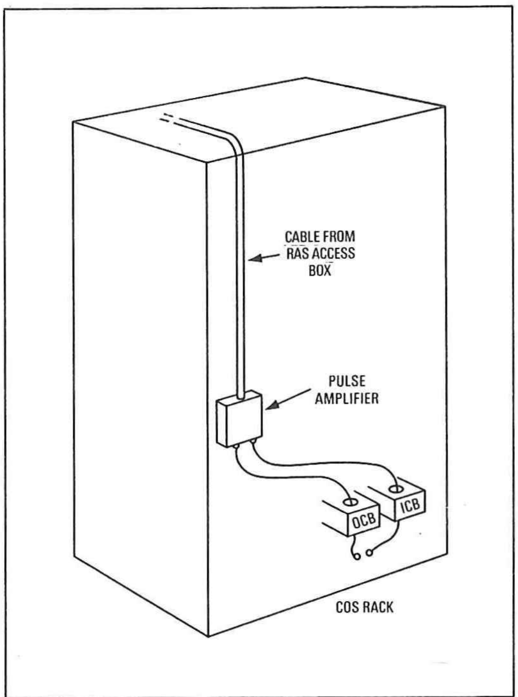
DN information from the interface is loaded into the PIO of the CPU board, together with an interrupt request (see software description). The system software, residing in EPROM (erasable and programmable read-only memory), now compares the DN with a number table, which contains all the directory numbers required to be acted upon by the RAS. If, after the DN from the exchange has been compared with all the numbers held in the number table and no match has been found, then no further action is taken.

If a match is found, then a pulse is sent to one or both of the two pulse amplifier circuits situated on the class-of-service (COS) rack. This results in the appropriate action taking place in the exchange hardware.

Pulse Amplifier

A pulse received from the CPU board is amplified by one (or both) of the two circuits and sent down a wire permanently threaded through the OCB or the ICB class-of-service rings. (See Figure 3.)

Figure 3
Class-of-service rack



When a pulse is received by the exchange on the OCB ring, then the DN which has just initiated a call is prevented from receiving dial tone by the normal exchange mechanism. Similarly, a pulse though the ICB ring results in a call to a DN being given number unobtainable tone (NU).

From the above it can be seen that, if pulses are received from the CPU board on both OCB and ICB rings, then the DN which has prompted this action must be made TOS.

Timing

When a DN goes calling (or is called) under normal exchange operation (that is, without the RAS fitted), then between the time that the DN is signalled to the primary decoder and the exchange interrogates the COS field, two reed relays have to operate. The operate time of a reed relay is approximately 1–2 ms; this means that the whole of the RAS operation must occur within this operating time-scale. To achieve this, two design details should be noted:

(*a*) decoding from two-out-of-five code to BCD is carried out by hardware, and

(*b*) the software is written in machine code, with a fast search routine using the minimum number of machine cycles.

Modem

A British Telecom (BT) 1200 baud modem is used to connect the RAS to the public switched telephone network (PSTN). This enables the system to be accessed by any similarly equipped terminal (note that password entry is required).

Since, the RAS can be turned into a terminal device itself (see software description), the modem can also be used to dial out to obtain access to any other similarly equipped exchange.

SYSTEM SECURITY

The RAS is made secure by the following:

(*a*) It is connected to the exchange via a 50-way insolation displacement connector (IDC). This means that the system can be disconnected from the exchange, and results in the restoration of the DNs to normal working.

(*b*) The number table in the RAS (because of its volatile nature) is backed up by a cassette tape. On the version to be produced by BT Fulcrum, non-volatile storage will be battery backed RAM, or floppy disc. This also enables the RAS equipment to be changed under fault conditions.

(*c*) The whole of the RAS circuitry is powered from the battery supply of the exchange.

(*d*) A self check is made, and an alarm output is given to the exchange alarm system.

(*e*) Password entry is required before any DN is affected.

(*f*) A printer is provided to give the following information:

(*i*) A list of all DNs known by the system, together with information about whether they are OCB, ICB or TOS.

(*ii*) A print-out showing when DNs have been input or restored from the system.

(*iii*) A message facility allowing a short message to be typed by a remote user to indicate to the Technical Officer for the exchange that work has been carried out.

SOFTWARE

Description

The control program is written in machine code to facilitate the following requirements:

(*a*) to maximise the speed of operation of the service interrupt routine,

(*b*) to enable full access to the operating system of the computer, and

(*c*) to enable the whole package to be contained in EPROM and therefore to be available instantly on system power-up.

The control program is approximately 3·4 Kbytes in length and fully integrated in the operating system, making a total length of 5·5 Kbytes. The Z80 CPU is operated in interrupt mode 2, with a clock speed of 4 MHz. The computer and the interface are connected together by 2X8 bit parallel data ports with handshake signalling. The control program is fully menu driven and provides the following:

(*a*) Dual password access to the RAS system (high and low level).

(*b*) The full exchange DNs to be made OCB, ICB and TOS can be entered into the unit directly via the computer keyboard or remotely via a terminal and modem arrangement. Data input from a modem is echoed back to it with seven data bits/even parity protocol, to provide full duplex working with remote terminals. All data entries for storage are fully error checked against the exchange numbering scheme before the data store is itself checked for an identical directory number entry. Any errors or duplicate entries provide the relevant error message on the system visual display unit (VDU) and printer.

(*c*) A facility to list the contents of the data store on the system printer.

(*d*) A facility to leave messages for maintenance staff on the system printer (local or remote).

(*e*) A facility to search the complete data store to check for a suspected entry.

(*f*) A facility to delete any number(s) from the data store and restore service.

(*g*) A facility to load system variables and the contents of the data store to and from a back-up cassette recorder.

(*h*) A facility to use the computer keyboard and modem to access a distant RAS unit without the local RAS operation being affected.

(*i*) A facility to alter passwords (locally or remotely).

Operation

Control Program

The control program runs in a loop that continuously scans the keyboard and serial input port checking for input data. It can be interrupted at any time by the interface.

Entry into the system is achieved by a carriage return (0D hex); after this, an exchange and system identification message is output followed by a request for a password entry. The next input of ten characters is then checked against two internal password stores. A match with either store results in the user being presented with one of two menus depending on which password store is matched. A '*** BAD PASSWORD ***' message results in the case of an unsuccessful access attempt.

Method of Data Storage in Memory

Only the thousands, hundreds, tens and units digits are stored in memory; any remaining digits are stripped off. The thousands and hundreds digit are compressed into one byte, and the tens and units digit into a second byte. A third byte is used to store the required condition; that is, OCB, ICB or TOS. For example, if the address of the start of the data table was 6000 hex and the table contained the entries for DNs 830290 and 834221 and, if both numbers were made TOS, then examination of the machine memory would show:

6000	A2	9A	03
6003	42	21	03
6006	FF	FF	FF
6009	FF	FF	FF
600C	FF	FF	FF
600F	FF	FF	FF
	etc.		

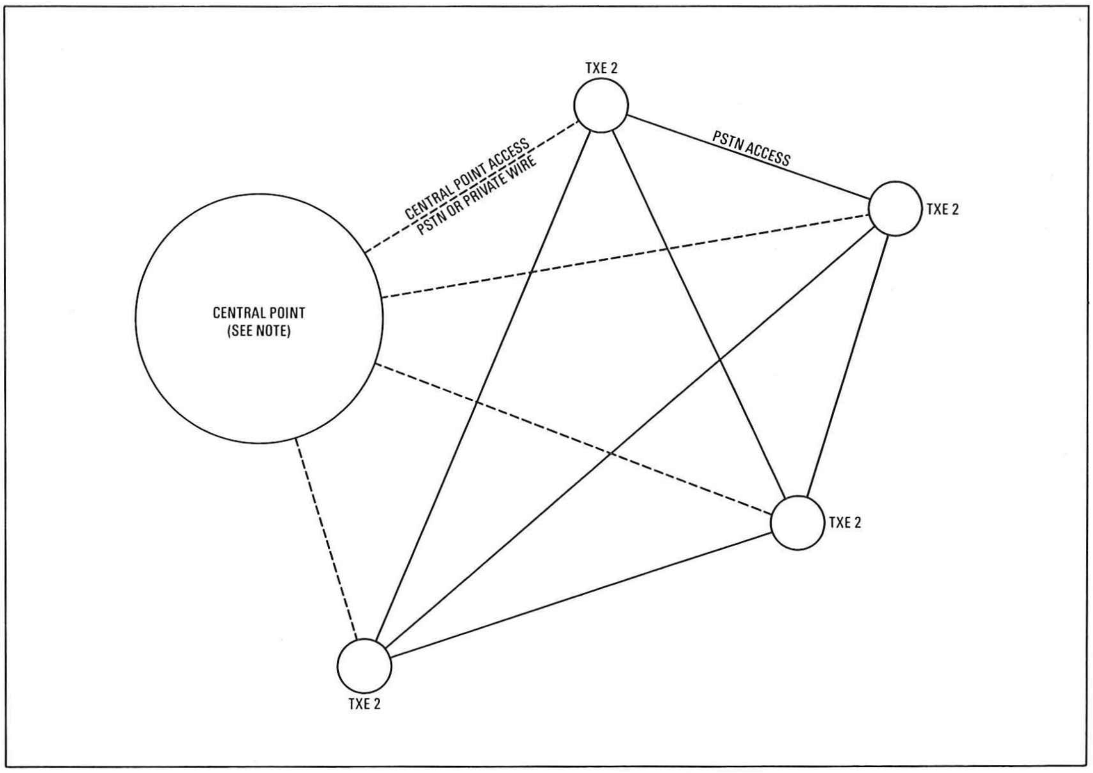
This method of data storage has two advantages. Firstly, it is in exactly the same format as that provided by the interface unit, and secondly it is the most economical in terms of memory bytes.

Service Routine

An interrupt signal generated by the interface causes the Z80 CPU to push the next instruction address onto its stack and to jump to the service routine start address. The main task of this routine is to load BCD values into the workspace memory of the CPU. The data loading routine contains several delay periods to ensure perfect synchronisation with the exchange data highways and hence to prevent any errors being read. The data is read into the machine in double-number byte format, thousands/hundreds, then tens/units, from the register-to-decoder highways of the exchange. The data is changed by hardware in the interface from BT two-out-of-five code into a form of BCD (0 is represented by A hex) as previously stated; handshaking between the two units ensures synchronisation.

The service routine then instigates a very rapid memory search routine. If the data just loaded matches any of the numbers in the data store, then the control byte for that number is loaded into the interface unit. This

Figure 4
RAS access—PSTN access gives maximum flexibility, or single point access can be used



Note: The central point can be a repair service control/group switching centre, System X operations maintenance centre, Customer Service Systems (CSS) District information systems unit

signal is then input to the pulse amplifier located in the exchange COS rack as previously explained. If no match is found during the search, then no output signals are sent and no action is taken by the exchange hardware. On completion of the search, a flag is tested. If the VDU is not being used by an operator, then the program prints the highway information (thousands hundreds tens and units) on the VDU, but not on the printer. Alternatively, the printing process is omitted for obvious reasons. The service routine is then terminated and the program returns to its original flow.

CONCLUSIONS

The RAS has been introduced into four TXE2 exchanges in the Lancs and Cumbria District as a maintenance aid for use by the exchange Technical Officers. (See Figure 4.) It has resulted in reductions in travelling time, and hence savings in maintenance costs at these exchanges are being shown.

The RAS is to be introduced into most of the remaining 50 TXE2 exchanges in the District, as soon as a supplier can be found (BT Fulcrum is currently negotiating to manufacture the RAS as part of its product range).

ACKNOWLEDGEMENTS

The authors would like to thank Mr. M. Butters for his assistance with the project and for the production of the user guide.

Biographies

Bill Entwistle joined BT as a technical apprentice in 1969. He has worked on the maintenance of exchanges including TXE4A. In 1971, he obtained a full technological certificate at Preston Polytechnic and joined the IEEIE. In 1986, he was promoted to level 1 on the District support group for TXE4/4A.

Peter Chamberlain joined BT as a technical apprentice in 1967. He has worked mainly on Strowger maintenance, but has a keen interest in writing computer software. He is currently employed as a Technical Officer on exchange maintenance.

System 4 Automatic Radiophone

J. J. NEWTON†

UDC 621.396.6 : 621.395.4

This article outlines the System 4 automatic mobile radio service in the UK. It describes how the original manual Radiophone service was converted to automatic direct-dial working, initially in the London area and subsequently to provide a nationwide service.

INTRODUCTION

British Telecom (BT) opened its System 4 automatic mobile radio service, formerly marketed under the name of *Radiophone*, in 1981. About 10 000 customers benefit from a very high frequency (VHF) network which extends further into rural areas than either of the competing cellular systems is able to do economically. The service has a total of 110 duplex channels at 12·5 kHz channel spacing and uses the system known as the *mobile automatic telephone system* (MATS-B)

Customers are able to dial national and international calls, and to receive calls from any UK telephone, but at present they cannot receive international calls. Investment in the system continues: a new regional structure, with new exchanges was introduced in 1986, and further possible developments are being studied.

Although it was originally a London-only network, System 4 is now planned and marketed as a low-density nationwide system with good coverage of rural areas, as opposed to cellular systems which are better situated to high-density urban operation.

BACKGROUND

MATS-B was developed by TeKaDe (now part of Philips Kommunikations Industrie AG) in West Germany. The BT system is one of about six MATS-B systems in use in the world, but is the only one to use 12·5 kHz channel spacing: other administrations, notably in the Netherlands and West Germany itself, use the more conventional 25 kHz channels.

Unlike the West German system, which is based on individual cities, System 4 is operated in seven independent regions or zones, with exchanges in each region connected to a large number of base stations to give extensive coverage.

System 4 is operated by BT under two licences held by British Telecommunications plc. BT is allowed, under a licence issued by the Home Office under the Wireless Telegraph Act, 1949, to make radio transmissions from, and to, base stations and mobiles. The Home Office charges £5000 a year for each of the 110 channels which are in the 160 MHz band. The second licence, under the Telecommunications Act, 1984, is issued by the Department of Trade and Industry and can be revoked if four years' notice in writing is given.

Unlike the cellular systems, BT is both the network operator and system provider for System 4.

HISTORY

The first UK Radiophone service opened in South Lancashire in 1959, with a London service following in 1965. This was a manual system, later designated *System 1*, and catered for only 320 customers in London[1]. A more advanced manual service, System 3, opened in 1971. System 3 used an initial 37 half-duplex channels with 25 kHz channel spacing. In 1973, a further 18 speech channels were introduced. One of the 37 channels was used for control signalling, with the other 36 available for speech.

Capacity was increased by replacing the earlier mobiles, which were restricted to one signalling and nine speech channels, with more advanced equipment able to access all 55 channels[2]. But even so, the system quickly reached full capacity, particularly in London where 3264 mobiles were accommodated in December 1978—over half the nationwide total of 6052. The next biggest area was the Midlands with 819. The Grampian area, running up the east coast of Scotland from Dundee to Inverness, had 53.

The need for an automatic system was seen with the aim of increasing efficiency and reducing operating costs. In addition, more than 55 channels were required, but the Home Office would not allocate more of the radio spectrum for an automatic system, so it was necessary to adopt 12·5 kHz channels, which would ultimately allow 110 channels to be used. The decision was taken to run System 3 and System 4 in parallel until System 3 could be closed.

† Head of System 4, British Telecom Mobile Communications

TRANSITION FROM SYSTEM 3

Several of System 3's 25 kHz channels were taken out of service in preparation for the introduction of automatic working. This process had to be carried out carefully, as many of the old nine-channel mobiles were still in use and it had to be arranged that each base station continued to radiate channels that were available to all users.

The released channels were used to inaugurate the System 4 service, initially in the London area only, with the new spacing of 12·5 kHz between channels and 4·5 MHz separation between the two transmission paths.

In January 1983, dealers were given three years' notice that System 3 would close; existing customers were told a year later. The system closed in England and Wales on 31 January 1986, but was maintained in Scotland for almost a year longer to enable System 4's coverage to be extended beyond that of System 3, which then closed in Scotland on 30 December 1986.

DEVELOPMENT INTO A NATIONWIDE SYSTEM

System 4 started in London in July 1981. For almost two years, it was considered as essentially a London-based system with limited access outside the capital. Roaming facilities were introduced to allow London customers to make calls from other areas; base stations were installed in the Solent and Birmingham areas in early-1982, but local marketing was kept to a minimum.

Demand for service was so high that the saturation point was reached in late-1982, and a waiting list for service began to grow. By 1984, there was a black market in cars equipped with System 4 Radiophone equipment. The pressure on London eventually eased in the spring of 1985, a few months after the launch of the two cellular radio systems. The waiting list was cleared in March 1985, though the number of customers in London continued to grow until it peaked in May 1985.

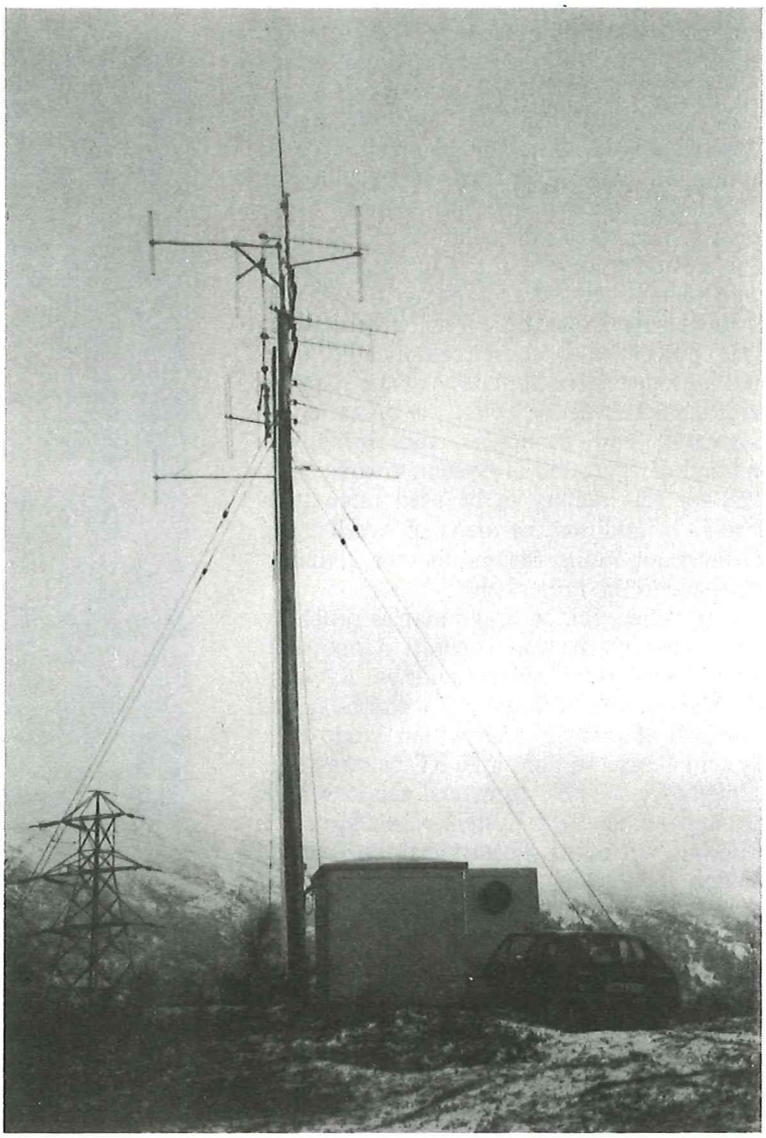
In July 1983, the system was extended to include such cities as Aberdeen, Edinburgh, Glasgow, Manchester, Leeds and Cardiff. However, in this second phase of development, there were still wide gaps in coverage along the routes between cities and in other rural areas.

The concept of System 4 as the first nationwide Radiophone service developed and went into operation from 1983 onwards. The number of base stations was increased from 30 to 60 to provide the extension of service to the major urban areas, and work began to provide coverage along the major motorways. This enabled customers based in the main conurbations to use their radio telephones more extensively across the country, which provided a further stimulation for sales.

The process of installing new base stations has continued in order to bring mobile telephony to areas which had previously no access to such a service and to improve the service in some fringe areas. Figure 1 shows one of System 4's more remote base stations, installed in December 1986 to cover the A9, A86 and A889 roads. In late-1986 and early-1987, coverage was extended to wide areas of Cornwall, North and South Wales, Lincolnshire, and Northumberland. Further decisions have to be taken about extending coverage to the Lincolnshire and north Norfolk coastlines and to include the east–west transport links in northern England.

System 4 base stations, with an effective radiated power (ERP) of 25 W, can provide coverage over an area up to 55 km from the base, depending on the nature of the surrounding environment. However, traffic needs and topography generally combine to restrict the radial range of a typical base station to about 20 km.

Figure 1
One of System 4's more remote base stations, at Newtonmore



Unlike cellular radio systems, System 4 currently has no hand-off facility to switch calls to the next base station when a mobile starts to move out of range. However, a trial hand-over facility is currently being tested between Reigate and Brighton. If successful, this facility will be extended to some other areas, but as System 4 base stations, in both rural and urban areas, generally cover a far greater area than their cellular counterparts, a mobile is much less likely to move out of range during an average call.

On longer calls, it is up to the callers to decide the point at which the signal strength, and therefore the audio quality, have deteriorated beyond an acceptable level. At that point, a new call must be set up: the system will find the best possible channel available. System 4 is rugged enough to hold a link once set up until well after conversation becomes inaudible. There is no risk, as there is with cellular systems, that the call will suddenly cut off without warning as the mobile moves away from a base station.

There are ways in which a mobile customer, when beginning a call, can ensure that transmission is maintained for as long as possible. This is achieved by over-riding the normal automatic selection procedure. The customer can select instead a base station towards which the mobile is moving. Each base station transmits continuously an *idle marking signal* (IMS) code on all vacant channels used in setting up calls. There are seven different IMS codes, which allow base stations to be identified within a particular restricted area. The customer enters the appropriate IMS code to instruct the radiophone to select a channel only from the chosen base station. This procedure is more complicated than making a normal radiophone call and requires additional knowledge about the operation of System 4. Few customers understand the method of operation of System 4 sufficiently well for this facility to be used more than rarely. In addition, in areas of overlapping coverage, it limits the number of channels available to the radiophone.

In practice, the coverage map is probably drawn conservatively and operation is possible beyond the advertised boundaries. By late-1986, about 93% of the population of England, Scotland and Wales was within range of a System 4 base station, and BT believes that it might be possible to extend this coverage profitably to 96–97%. System 4, like System 3 before it, has never served Northern Ireland, though there were once plans to build two base stations in the Belfast area.

ZONAL STRUCTURE

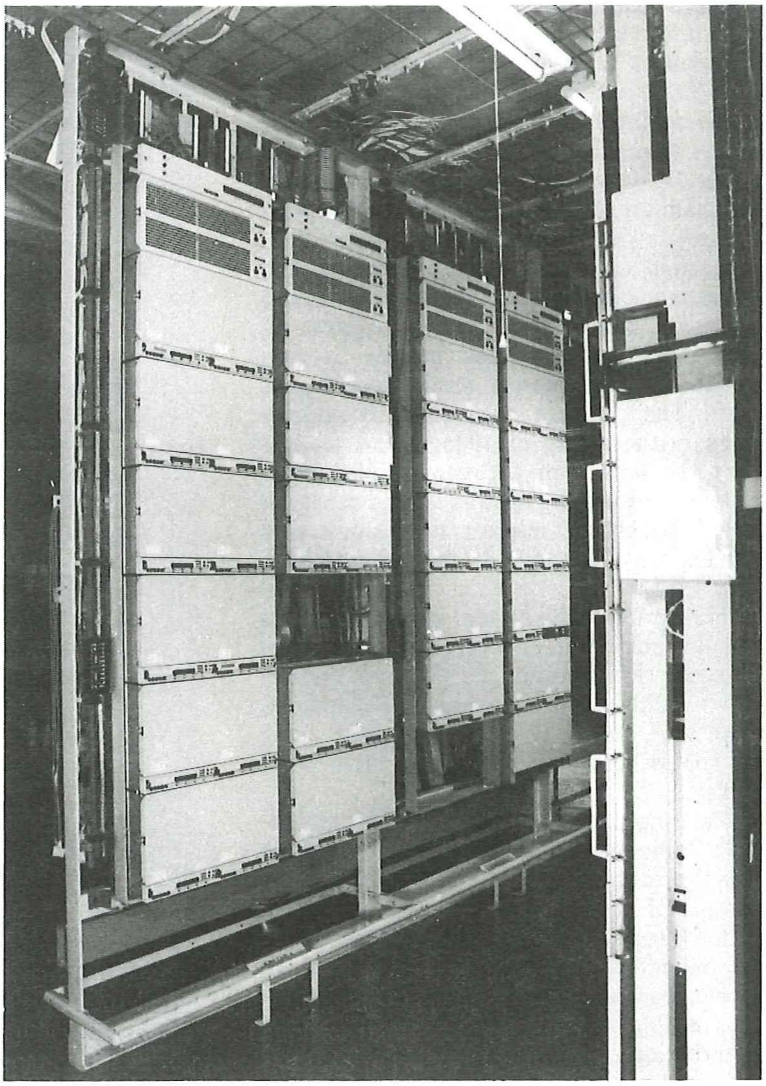
A zonal structure was introduced from 1983 onwards as System 4 was developed into a national network. In many ways, this resembles the regional structure of the earlier System 3, which was managed as a series of discrete areas, but it has the added benefit of allowing customers who opt for the facility to roam; that is, to make and receive calls away from their primary zone.

At first, the zone structure was fairly simple outside London. One zone covered South-East England, another the Midlands with parts of South Wales and South-West England, and there were two linked zones covering Northern England and Scotland. Customers in Scotland also had full access to the network in the north of England and vice versa.

Separate TeKaDe exchanges, known as *Radiophone control exchanges* (RCEs), were located in each zone to provide service: at Esher, Surrey, for South-East England (a shared site with the London System 4 exchange); in Birmingham for the Midlands; and in Bradford, with a line concentrator in Dundee, for the north of England and Scotland. All base stations in a particular zone are linked by leased line to the zonal exchange. Each RCE can serve no more than 42 base stations and 96 radio channels. (See Figure 2).

Each exchange has a separate area code, which means that callers need to know where

Figure 2
Part of a System 4 exchange



a System 4 mobile is so that they can dial the right area code. The six-digit telephone number of the mobile, however, remains unchanged nationally.

Customers could pay for service (covering both incoming and outgoing calls) in one zone, or any combination of zones. This allowed quarterly rentals to be introduced which were substantially lower than those that would apply to a nationwide service allowing universal access. South-east zone customers were allowed to make calls in London, but not to receive calls—only customers who had paid for nationwide service, which was equivalent to the original London-only service, could receive calls in London.

In subsequent years, the zonal structure has been refined. The south and east of England are now separate zones. On 1 April 1986, the Scottish zone was split from the North of England. Since then, the consequent reduction in charges and the increase in locally available channels have helped the number of customers in the North to grow by 25%. A zone covering Wales and the West of England has been split from the Midlands (see Figure 3). Because of these changes, new area codes have been introduced, see Table 1.

Figure 3
System 4 coverage

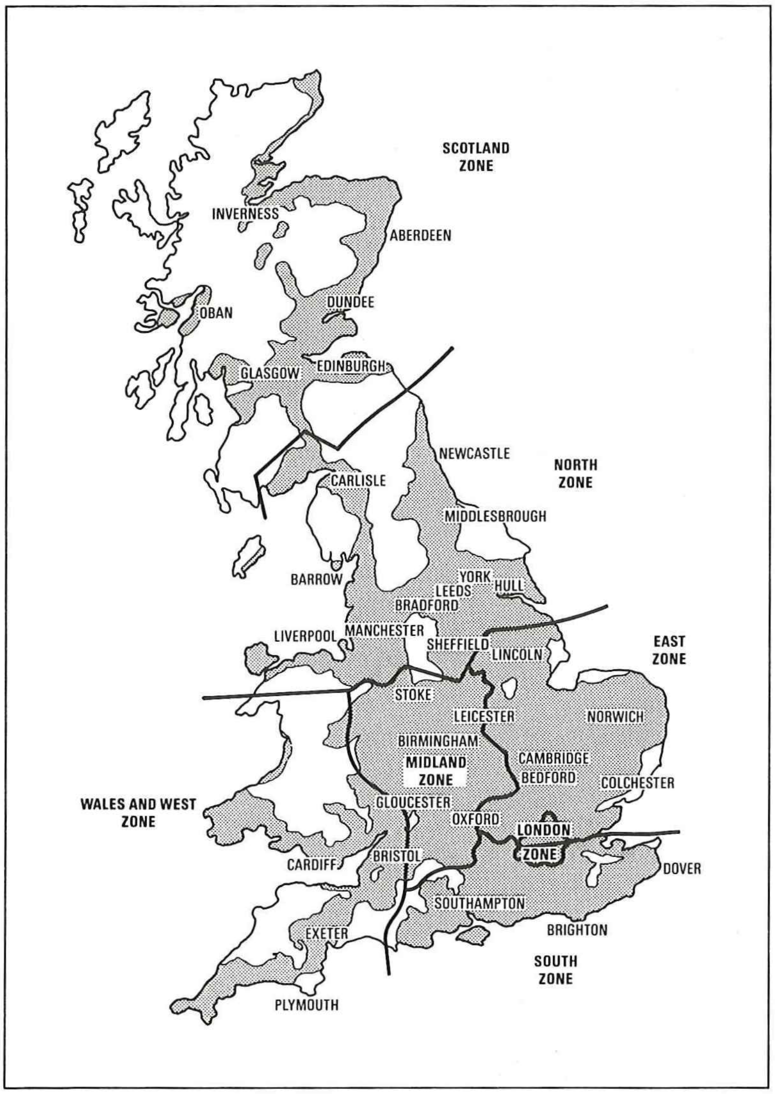


TABLE 1

System 4 Area Codes and Exchange Location

Code	Zone	Exchange Location
0033	East	Esher
0034	London	Esher
0035	Scotland	Dundee
0036	Midland	Birmingham
0037	North	Bradford
0038	Wales and West	Cardiff
0039	South	Esher

Access in London has also been modified. Customers who pay for service in the south zone can make but not receive calls in London south of the River Thames; those who pay for service in the east zone are similarly served north of the Thames. To receive calls in London, customers must opt for full nationwide service, which covers all zones. As the typical ratio between outgoing and incoming calls is three to one, many London customers are happy simply subscribing to the south and east zones, at a cost of less than half the quarterly charge for nationwide service, see Table 2.

TABLE 2

System 4 Quarterly Service Charges

Zone	Basic Zone	Additional Zone
National†	£200	n/a
South*	£50	£25
East‡	£50	£25
Midland	£50	£25
North	£40	£15
Scotland	£35	£10
Wales and West	£35	£10

Notes: Prices current at 1 January 1987
† Includes ability to make and receive calls in London. No other zone allows reception of calls in London.
* Includes ability to make but not receive calls in London south of the Thames
‡ Includes ability to make but not receive calls in London north of the Thames
Registration—There is an initial registration fee of £50 per mobile

Call Charges

Peak/standard rate: 7p for 15 seconds for first minute, 10p for 15 seconds thereafter.
Cheap rate: 4·5p for 15 seconds.

Because the range of the System 4 base stations depends on the local topography, the boundaries between zones are not rigidly defined in practice. In many cases, calls can still be made and received even when a user is some distance inside a different zone, as long as there is an adequate signal from a base station in a zone for which service has been paid.

OUTGOING CALLS

Each base station transmits a continuous signal on all traffic channels that are currently free and available for use. When a mobile customer wishes to place a call, the mobile equipment automatically scans the 110 channel band to seek a free channel. If more than one is available (possibly from more than one base station), the mobile selects the strongest signal. This process typically takes about two seconds.

The mobile transmits the number dialled plus its own number on the channel. The base station transmits all this information back on the other half of the duplex link, and the mobile carries out a comparison. If the received numbers do not match the transmitted numbers, the mobile abandons the link and searches for another channel. The process is repeated until a satisfactory link is acquired. Some mobiles are capable of scanning the full band twice in order to achieve a connection. The base station checks via its zonal RCE that the mobile is authorised for service in that zone.

Once a satisfactory link is achieved, the number dialled is passed through the RCE into BT's trunk network. All System 4 exchanges are sited at group switching centres. Callers have to dial the full national number of the customer they require, even when making a local call.

Reliability of the base stations is high, with service availability measured at about 99·7%. Only one exchange has so far suffered a major breakdown—a brief failure in 1982. The proportion of calls blocked during the busiest hour is targeted at not more than 20%. Traffic is monitored for each base station on tape, and where necessary the channel capacity of a station can be increased. For greater growth in demand, new base stations can be installed to relieve congestion on neighbouring stations, as long as there is remaining capacity in the TeKaDe exchange. The exchanges themselves are not capable of expansion beyond 96 channels.

CHARGING

All calls are charged at a uniform rate, although there is a reduction for off-peak calls. International calls are charged at the standard BT rates plus a percentage premium. Information about calls—time, duration, called number—is recorded on tape at the System 4 exchanges and then processed at a central billing centre.

Customers get fully itemised quarterly bills, which show national and international called numbers, and identify destinations in the case of national calls.

INCOMING CALLS

As already stated, the zonal structure of System 4 means that, in order to make a call to a mobile, it is necessary to know the zone in which the mobile is located so that the appropriate area code can be dialled. The RCEs are not linked, and if a mobile cannot be contacted within the zone covered by the exchange dialled, there are no facilities for forwarding the call to other zones. However, in practice, this has not proved to be a problem, as most System 4 customers opt for only one or two zones: hence there is rarely much scope for doubt about the number to dial.

The RCE then selects the base station within its zone through which to route the call. A process akin to radiopaging is used, on one dedicated channel out of the 110 available. This channel is used on a time-division basis by all base stations and is kept free of normal telephony traffic. Each base station is allocated to one of seven groups, in a distribution designed to ensure that the paging signals of no two base stations of the same group can interfere.

All mobiles, when switched on but not setting up or carrying a call, automatically tune to the paging channel, and listen for their own number. The paging sequence takes about two seconds for all seven groups. Each base station in a group transmits the number of the mobile sought plus the designation of a channel which is available for conversation and which it is monitoring. A paged mobile, on receiving its number, responds by switching to that channel and acknowledging the call.

Occasionally, the traffic levels are high enough for the paging system to build up a brief queue. The caller then hears a recorded announcement which states that the call will be put through as quickly as possible.

Once the link is established, the mobile rings. If the mobile customer does not answer within one minute, the call is abandoned without charge to the fixed caller. Calls which are connected are charged at a uniform rate independent of the location of the fixed customer or the mobile—the same rate as is charged to cellular customers. No charge is payable by the System 4 customer for incoming calls.

INTERCONNECTION WITH TELEPHONE NETWORK

The 4-wire System 4 radio system is connected to the 2-wire telephone network via a special interface. Electronic control is applied

to ensure the speech level from both callers is constant and thus achieve maximum audibility by obtaining as good a signal-to-noise ratio on the radio circuit as possible. However, this does have disadvantages. The mobile caller's voice is picked up from the interface and fed back to the mobile via the local control circuitry. Thus, when the fixed caller is not speaking, all noise on the mobile-to-base link is amplified and is also heard on the mobile. System 4 engineers are taking steps to overcome these problems.

Customer awareness of these problems has arisen only since the introduction of cellular radio systems, allowing a comparison to be made. But the development of cellular telephones has potential spin-off, notably in the area of miniature companders. The extension of BT's digital trunk network—System 4 currently interfaces with Strowger exchanges—should also bring improvements.

The significance of these problems should not be overestimated because the single biggest cause of interference with both System 4 and cellular mobile telephony is in poor installation of customers' equipment. Particular care has to be taken with System 4 installation as vehicle panels and chassis parts can produce interference with duplex VHF transmission and reception.

SUPPLY AND MARKETING OF MOBILES

When System 4 was launched, BT ran the network, but customers obtained their mobile equipment from independent suppliers, including Philips, Marconi and Storno. From 1983, however, when it was decided to make System 4 a nationwide service, BT started to market its own range of mobile telephones. The first, *Emerald 1*, manufactured by Mobira but sold by BT, was introduced in April 1983. A joint development with Philips led to the introduction of the *Sapphire* in 1984–85, and *Quartz* (see Figure 4) from Dancall was included in the range from mid-1985.

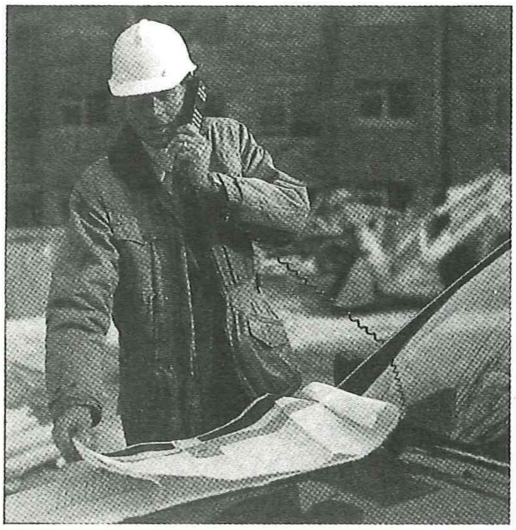


Figure 4
***Quartz* in-car mobile phone**

Particular features of the *Quartz* include:

on or off-hook dialling,
audio monitor,
last-number recall,
99 number store,
visible and audible signal to indicate incoming call,
service light that shows when mobile is in Radiophone coverage area,
handset volume control,
three-level electronic security lock to guard against unauthorised use, and
dual-tone multi-frequency dialling to allow keypad to be used as access to facilities such as Voicebank®.

Because of the restrictions of the 4-wire/2-wire interface between the RCE and the GSC, hands-free telephones are not currently possible, as these would suffer from audio feedback. The power requirements—3·5 A at 12 V—also make portable telephones impractical. Some System 4 mobiles have been fitted into briefcases, but these have to be powered from a vehicle lighter socket.

BT markets through its own Districts and independent dealers. Over 100 dealers registered users onto the system in 1986. About 40 dealers do significant levels of business, but it is hoped that the number can be increased to 70–80.

After the relaunch of System 4 in April 1986, with a reorganised regional structure, it is hoped to expand the number of users in the short term to 12 000. In the longer term, a target of 15 000 is believed reasonable, and up to 18 000 could be accommodated without degrading the level of service.

FURTHER DEVELOPMENT

With its extensive coverage of rural areas, considerable potential is seen for the use of System 4 in public transport. British Rail has experimented with System 4 coin-operated payphones on several Inter-City routes, but has recently decided to standardise on card-operated cellular telephones. However, there is interest in providing System 4 radiophones on major provincial routes, where cellular networks have poorer coverage.

System 4 payphones are already in use on Sealink Isle of Wight ferries. The telephone was developed by System 4 technical staff from the standard Payphone 200 tabletop unit. Its operation, apart from the coin-collecting mechanism, differs from normal mobiles in that it continually hunts for a free channel and provides a visual indication when service is available. If another mobile starts to use the selected channel, the service indicator goes out until another channel is found.

Further applications are sought on long-distance coaches, particularly those not using the motorways which are well covered by the cellular systems, as well as on other ferry

routes and on commercial fishing and other coastal vessels. The range of System 4 base stations over sea appears quite extensive—up to 140 km has been reported by one dealer. Several installations have been made on vessels and on gas production rigs which are located close to the coast.

There is also believed to be some scope for data transmission via System 4. The technical feasibility has been established: indeed, System 4 scores heavily over cellular radio in this respect. Hand-off between base stations on the cellular radio system, and other control signals, cause an interruption in the conversation, or data stream, for 300 ms. This puts particularly strenuous demands on the modem design.

CONCLUSION

The System 4 direct-dial radiophone service is a fast and efficient means of communication for business people on the move. The service is available nationwide through a series of seven zones, and utilisation can be tailored to suit individual needs. Calls can be received automatically from any telephone in the UK. The full range of outgoing calls, including international direct dialling facilities, are available. The service is complementary to the cellular radio systems, particularly in the less populated rural areas where it is able to offer excellent coverage.

BIOGRAPHY

Jeremy Newton joined BT in 1973 and was appointed Head of System 4 Radiophone in BT's Mobile Communications Division in June 1986. Previously he had been with the Consumer Product Division concerned with sales and marketing support for the distribution network. He is a member of the Institute of Marketing.

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The Impact of Telecommunications on Economic Growth in Developing Countries

This article is based on an interview with Mr. Walter Richter, Economist in the Technical Co-operation Department of the International Telecommunication Union (ITU), and published by the Public Relations Division of the ITU as a press feature for the forthcoming World Telecommunications Forum at TELECOM 87, in Geneva later this year.

What is the impact of telecommunications on economic growth? Anyone may give an intuitive answer to this question. Paradoxically, however, although no one is in any doubt as to what the answer should be, there are few studies which can give a scientific explanation of the phenomenon.

And yet it has now become essential that developing countries should be presented with irrefutable proof of the importance of telecommunications—especially telephone and Telex—for their economic growth. Why should this be? This is the question put to Mr. Walter Richter, Economist in the Technical Co-operation Department of the International Telecommunication Union (ITU).

The greater the shortage of foreign currency in developing countries, the more difficult it will be for their governments to select priorities. The readily available means in the first place will clearly be devoted to meeting prime necessities, such as food, medical care, etc. Any further means will have to be divided between tasks such as education, transport, telecommunications, etc.

In this distribution, it will be found that the means allocated to ministries of telecommunications are invariably inadequate. In addition, there is the fact that in this particular field investments are relatively costly.

This subject was debated at the Plenipotentiary Conference in Nairobi in 1982, and one of the conclusions reached was that ministries needed arguments which could help them prove the socio-economic usefulness of telephone links.

Hence the mandate entrusted to the ITU.

What has been your approach to this problem?

The first clear fact to emerge was the uneven distribution of telephone densities, which in developing countries are on average ten times higher in towns than in rural areas. Part of the population is even unaware of the very existence of telephones. Although the towns themselves are usually relatively well off, developing countries often cover vast territories which are predominantly rural.

Telephone investments and maintenance in urban areas are relatively cheap owing to the short distances between telephones. The reverse is true, however, in the countryside, where telephones are expensive to install. It may be preferable, therefore, to lay greater emphasis on justifying the need for telephones in rural areas and on demonstrating that this need is even greater there than elsewhere.

In your opinion, which are the relevant criteria in this respect?

Our most striking conclusion is that qualitative arguments are not enough. We feel convinced that our plea in favour of telecommunications can only succeed if it is quantified. This is why for many years now, and more especially since 1983, the ITU has been looking for suitable yardsticks to measure these phenomena, in an attempt to quantify the socio-economic benefits of telecommunications.

How does the problem look from the theoretical angle?

The first point is that installing a telephone involves on the one hand a certain usage, and on the other hand a tariff which determines the revenue arising from such usage.

The second point is that—at any rate in developing countries—the revenue which arises from the use of the telephone is almost invariably insufficient to cover installation and operating costs, a situation which is aggravated by the fact that investment and hence the repayment of loans depends on convertible currencies, whereas revenue consists of local currencies.

The conclusion which national PTT administrations tend to draw from this situation is that, since installing telephones in rural areas is unprofitable, it is to be avoided. It is easy to understand this kind of reasoning. Generally speaking, governments are reluctant to invest in activities which give rise to losses and which make ministers unhappy.

This approach, which consists of comparing telephone costs and revenues, may thus be said to provide an inadequate financial analysis of the situation.

What other arguments can be put forward?

The first one is that the real or expected benefit of telephone usage is much greater than the tariff-derived revenue and even exceeds the cost of investment and operation, especially if the telephone is compared with other facilities.

Could you enlarge on this point?

The best way of identifying the potential benefits of the telephone is quite simply to put the question to the people concerned, for instance by asking them:

- What would you have done if there had been no telephone?
- How much would you have saved if there had been a telephone?

From a broad enough sample of replies, a fairly clear idea will emerge of the benefits of the telephone as they are actually *perceived.*

But how do you arrive at a strictly economic line of reasoning?

There are several possible approaches:

- A microeconomic analysis.
- A comprehensive analysis establishing a correlation between the level of telecommunications development and the standard of economic welfare. For instance, a relation may be established between the density of the telephone network and average annual per capita income.

  This relation may be represented very clearly. It is even quite spectacular when seen as a graph. The trouble is, that it does not prove anything. It merely depicts a situation, without establishing any casual relationship.
- Another approach consists, for instance for an exporting country, in identifying the potential benefits of using a Telex, and in particular the kind of information which may then be obtained with regard to transport, prices, markets, etc.

  On the basis of concrete examples extrapolated on the scale of the country's total volume of exports, it is possible to arrive at the probable benefit to be derived from a telecommunications network.

In fact this third approach is the one we tend to prefer.

What conclusions have you reached?

The first is that every call from a public telephone in a rural area brings the user not only the equivalent of what he is paying, but also a supplementary benefit. This may be estimated to be of the order of 1 US dollar, which may be taken as an average arising from very variable conditions, with extremes ranging from 0·1 to 10 US dollars.

The cost of a telephone call, however, is still exorbitant. If a user, for instance, earns 1 rupee a day, he may be asked to pay two, three or even four times that much for a call. An equivalent situation would be for someone, for instance, earning 150 dollars a day, to have to pay 300 to 400 dollars for a telephone call.

Despite that, the economic benefit of the telephone for the user may be twice as much as he actually has to pay for the call, even if you consider only the cost of a trip which he has been able to avoid. It may be assumed that, if a very low income earner decides to devote such a considerable sum to a telephone call, it must be because he is very strongly motivated.

There is a further condition which must be fulfilled, namely that the *alternatives* to the telephone call cost more than the call itself. Most countries, in fact, have satisfactory land communications. The telephone would only be used, therefore, in cases where the alternative 'journey' either is prohibitively expensive or would not achieve the desired objective. We estimate that this kind of situation may arise for a user once or twice a year.

That seems to be very little. Is there no chance, then, of ensuring a reasonable return on a telephone connection?

The average cost for the PTT, calculated on a world-wide basis, of a telephone is of the order of 500 US dollars per annum. It may, however, go as high as 1800 US dollars in some countries. Most of the calls made from a rural telephone are long-distance calls, which cost on average 1–2 dollars. The revenue derived from a telephone connection, and hence the revenue-to-cost coverage ratio will depend on the number of calls made.

If we take as an example a country like India, where considerable research has been made in this field, the target arrived at by the authorities is one connection per 5000 inhabitants in remote areas and 1 per 2500 inhabitants in towns.

What else have you found?

All types of people use the telephone: women, unemployed, peasants, a priori no category of the population can be excluded.

In practice, however, we find that the most frequent users are those with above-average means, for whom a telephone call works out relatively cheaper. The majority of telephone users are in the higher income bracket.

What about businesses? Is their situation not different?

Obviously the telephone can provide other benefits for businesses. They can increase their turnover; they can sell more; they can win new customers; they can improve their productivity; they can reduce their prices and

increase their profits, and extend their geographical coverage.

If businesses are prepared to pay the price of a telephone, therefore, it is because for them it represents a vital necessity.

One of the best studies of the subject has shown that a whole network will be economically viable if 10% of its users are businesses.

It is estimated that the use of a telephone can save around 4% of a company's income, while costing only between 1 and 2%.

It may be worth noting that, while in industrial countries a business simply cannot work without a telephone, this is not quite the case in developing countries, where, with the socio-economic structure as it is at present, considering the dimension of villages and the existence of markets, etc., it is possible to do business without a telephone.

As soon as we have any degree of economic specialization in particular regions or businesses, however, then rapid telecommunications—in other words the telephone—become indispensable. Conversely, the installation of a telephone infrastructure can bring about modifications in the economic structure by enabling businesses working in specialised fields to survive, thanks to their broader coverage of customers and geographical area.

However convincing your economic arguments may be, they do not take certain qualitative factors into account. Why is this?

Quite simply because qualitative considerations depend on values and values give rise to controversy.

Take the example of health. What is the economic value of a human being? You may say that it is the value of what he produces less what he costs. In fact, the question may be answered quite differently depending on the culture concerned. What value can be attributed to a boy or a girl? In some countries it is very low and in others considerable. Opinions can differ substantially.

Take another example: the emergency situation in the Sahel. You can use the telephone to co-ordinate truck transport bringing vital necessities which can save lives. But what is a life worth? This is an emotive or a philosophical question.

Another value might be *national unity*. Yet in this case the telephone may be a double-edged instrument. It can be used just as much by rebels as by the government authorities. As for Telexes, these may be intercepted and read by people for whom they are not meant. Telecommunications may therefore be considered as a threat by certain regimes.

You see, since qualitative arguments are open to controversy, in the end it is the economic arguments which carry more weight and this is why we prefer them.

Would you say that the question of the economic justification of the telephone has now been finally resolved?

Certainly not. We are expecting a great deal from the forum which is to take place at TELECOM 87 and which is to include a symposium on this very theme. We are hoping to receive a lot of contributions which will help us to make headway in this difficult field.

One of the key questions to which we will have to find an answer is, for instance, how we can prove that introducing telephone networks can provide countries with new revenues in convertible currencies, whereas, as we saw earlier on, while revenues arising from telephone usage consist essentially of local currencies, loans have to be repaid in convertible currencies.

An Electronic Incoming Coder System for Mondial International Switching Centre

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UDC 621.395.344.6 : 654

This article describes an electronic incoming coder system which has been installed to replace part of the electromechanical common control of Mondial International Switching Centre, and, thereby, provide stored program control. In addition, the article describes some special features of its development, manufacture, and installation.

INTRODUCTION

Mondial International Switching Centre (ISC) is based on the Plessey 5005T 4-wire-switched crossbar system, and is classified by British Telecom (BT) as a TXK2 switching system. The switchblock is dimensioned to provide terminations for 10 000 incoming and 10 000 outgoing circuits, and to give a theoretical maximum busy-hour switching capacity of approximately 6000 erlangs. The original design of the common control was based upon electromechanical technology, using various types of relays. The electromechanical incoming coder (EMC), which forms part of the common control, and which is responsible for providing call-routing information, has been replaced on a 'one-for-one' basis, with an electronic incoming coder (EIC). The EIC uses an INTEL 8085A microprocessor, with opto-coupler circuitry for interfacing with other TXK2 common-control equipment. Two Digital Equipment Corporation (DEC) PDP11/23 Plus minicomputers, referred to as *updating systems* (UDSs), are provided (one of which is a stand-by) so that the EICs can be updated or interrogated by on-line commands.

The development of the system has been carried out 'in-house' by British Telecom International (BTI) personnel, as has the installation and commissioning.

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GLOSSARY OF TERMS

ASCII	American standard code for information interchange
CPU	Central processing unit
CT	Coder tester
CTAR	Coder test access rack
DEC	Digital Equipment Corporation
EIC	Electronic incoming coder
EMC	Electromechanical incoming coder
GO/GR	Group occupancy/group relief relays
GODR	Group occupancy distribution rack
IATAE	International accounting and traffic analysis equipment
I/O	Input/output
INMC	International network management centre
ISC	International switching centre
ITSC	International telephone services centre
LED	Light-emitting diode
P&Q	Incoming circuit identification code
PCB	Printed-circuit board
SIU	Slide-in-unit
UDS	Updating system
Zc	Route destination identification code

OBJECTIVES OF THE ELECTRONIC INCOMING CODER PROJECT

Because of the dynamic nature of the network connected to Mondial ISC, the call routing information held within the incoming coders must be changed frequently. Such changes to the EMCs are achieved by reconfiguring wire straps on the coder connect frame and other terminal blocks associated with each incoming coder. As there are 20 incoming coders, this is a slow and labour intensive activity. In addition, because the number of relays available was limited, and adding more was impracticable, certain enhanced facilities, which would be advantageous to BTI, could not readily be added to the EMCs.

Hence, the EIC system has been developed to meet the following objectives:

(*a*) to be able to change the routing data held in Mondial ISC by on-line commands from a visual display terminal (VDT);

(*b*) to be able to provide a range of network traffic management control facilities, which can be executed by on-line commands from a VDT;

(*c*) to be able to provide enhanced operational facilities (for example, special barring facilities and enhanced digit analysis capabilities); and

(*d*) to be able to implement any changes to the above exchange configuration data in a flexible and expeditious manner.

SYSTEM ARCHITECTURE FOR MONDIAL ISC

A simplified trunking arrangement for Mondial ISC is shown in Figure 1. (The operation of Mondial ISC was described in an article in a previous issue of the *Journal*†.)

FUNCTION OF AN INCOMING CODER

Mondial ISC is equipped with two types of coder: incoming coders, of which there are 20; and outgoing coders, of which there are four. The outgoing coders interwork with TXK2 transenders to provide a translation of exchange or area codes on calls to provincial group switching centres via routes using Signalling System AC9. Changes to the routing information held in outgoing coders occur very infrequently, and, for this reason, the electromechanical outgoing coders have not been replaced.

The main functions of an incoming coder are:

(*a*) to interwork with TXK2 registers and router controls to provide call routing information;

(*b*) to interwork with the international accounting and traffic analysis equipment (IATAE) associated with Mondial ISC to provide accounts for settlement with foreign administrations, and traffic recording information for the use of BTI; and

(*c*) to interwork with the TXK2 equipment monitor, to provide exchange fault print-out information when instructed to do so by a TXK2 router control.

An incoming coder provides call routing information by analysing the information presented to it by:

(*a*) a TXK2 register which has been associated with a specific call during the call set-up phase; and

(*b*) the group occupancy/group relief (GO/GR) relays, together with the GROUP BUSY keys, which indicate whether outgoing engineering route parts have a free circuit available.

The information presented by a register can be categorised as follows:

(*a*) digits received by a register—up to eight digits can be forwarded to the incoming coder, depending upon the type of call; and

(*b*) discrimination signals from a register, namely:

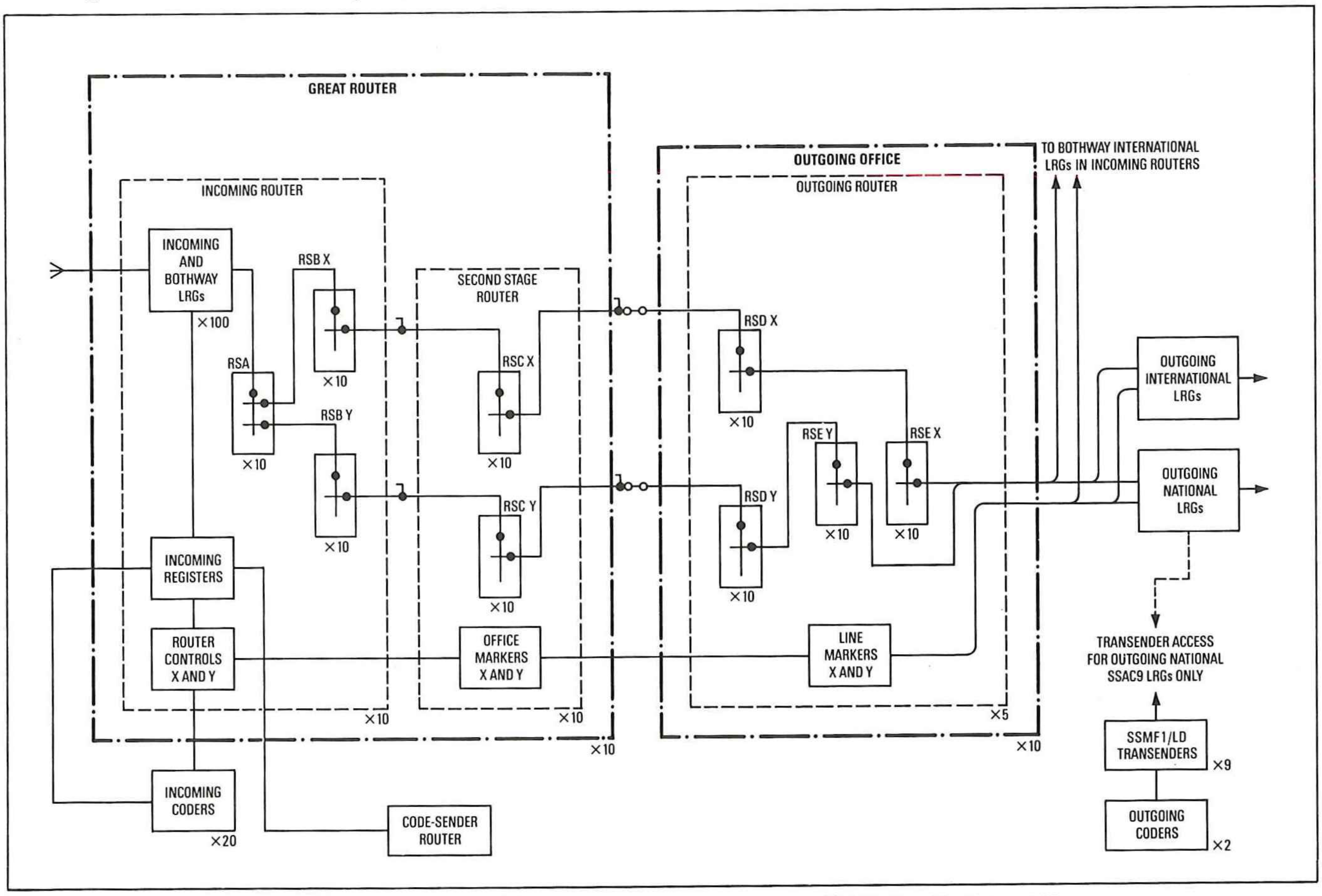
(*i*) type of incoming signalling system,

(*ii*) UK customer or UK international operator originated call,

(*iii*) call destined for the UK national network,

(*iv*) data call,

† MODI, D. C., and YOUNG, K. W. The TXK2 Switching System and Peripheral Equipment at Mondial International Telephone Service Centre. *Post Off. Electr. Engs. J.*, Jan. 1978, **70**, p. 248.



SSMF1/LD: Signalling System Multi-Frequency No. 1/loop disconnect SSAC9: Signalling System AC9
LRG: Line relay group

Figure 1
Simplified trunking arrangements at Mondial International Switching Centre

(*v*) echo-suppressor control information on incoming international calls, and

(*vi*) call originated by an exchange routiner.

The analysis performed by an incoming coder results in information, corresponding to one of the output categories below, being sent to the register and router control associated with the incoming coder at that time, namely:

(*a*) complete routing data (that is, a free outgoing circuit is available);

(*b*) spare code or force-release condition;

(*c*) extra digits are required in order to perform the analysis (an *extra digits called for* ouput signal is given);

(*d*) all outgoing routes for the chosen destination are busy; and

(*e*) under certain conditions (including certain types of fault within an incoming coder), no output is given, in order to force a router control to cause an equipment monitor print-out, and a second attempt via the partner coder if appropriate.

An output of the type category (*a*) above also results in information being forwarded to the IATAE, for accounting of the call if an *answer* signal is eventually received over the outgoing circuit.

INTERWORKING OF AN INCOMING CODER WITH OTHER FUNCTIONAL UNITS

The incoming coders of Mondial ISC are arranged in five quads, each quad serving two great routers. Each incoming coder serves ten incoming routers (making a total of 20 router controls, 10X and 10Y, served by each incoming coder). As the EMCs have been replaced on a one-for-one basis by the EICs, the aforementioned access and grading arrangements have been retained.

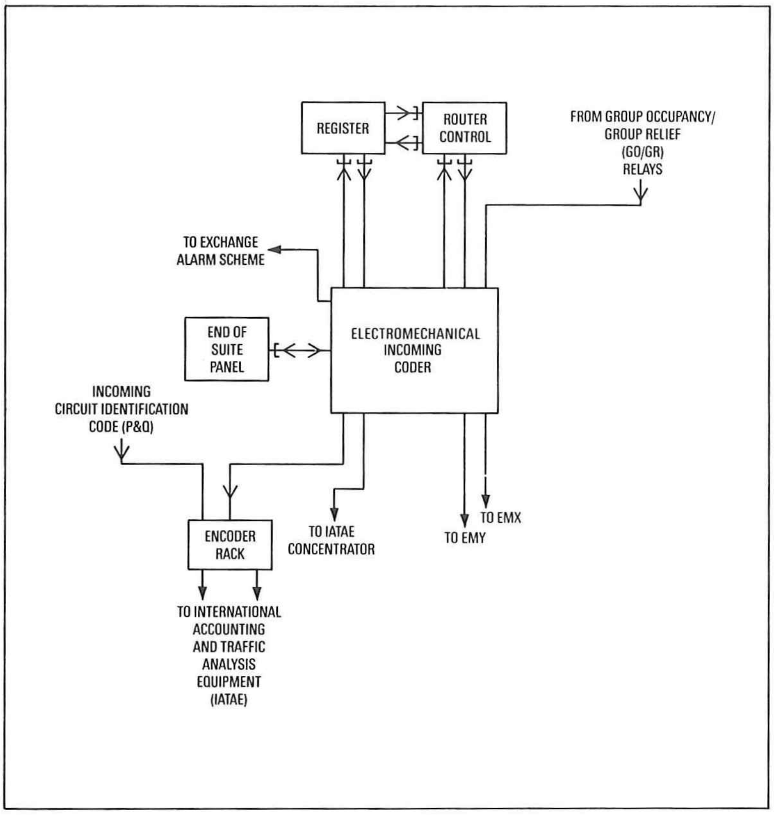
Figures 2 and 3 show how an EMC and an EIC, respectively, are interconnected to other functional units. The salient differences between the interconnection arrangements for the EMC and EIC are:

(*a*) a coder tester, which is connected to an EIC, via the coder test access rack (CTAR), when required, has been provided instead of the end-of-suite panel (which is provided per quad of EMCs);

(*b*) the route destination identification code (Zc) sent by an EIC to the IATAE for international accounting purposes is passed via 11 wires instead of the 661 used by the EMC;

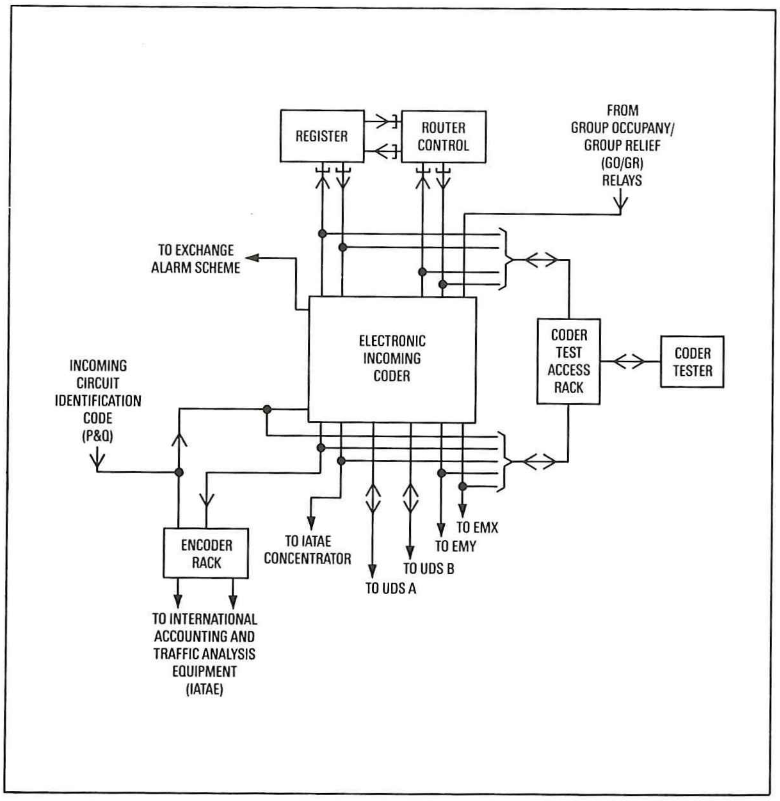
(*c*) each EIC is provided with a parallel feed of the P&Q (incoming circuit identification code) highways associated with its IATAE encoder rack (the P&Q information is used by the EIC for special call barring facilities); and

(*d*) each EIC has two serial links (using



EMX, EMY: Equipment monitor serving X, Y side of the exchange

Figure 2—Interconnection of an electromechanical incoming coder with other functional units



UDS: Updating system
EMX, EMY: Equipment monitor serving X, Y side of exchange

Figure 3—Interconnection of an electronic incoming coder with other functional units

TABLE 1
Interconnections Between the Incoming Coders and other Functional Units

Functional Unit	Electromechanical Incoming Coder		Electronic Incoming Coder	
	To Coder	From Coder	To Coder	From Coder
Router Control Selection	20	20+CF	20	20+CF
Router Control Highway	2	33	2	33
Register Highway	66+DLO+DLE	45	66+DL	45
EMX	–	65	–	65
EMY	–	65	–	65
IATAE	–	695	–	47
GO/GR Relays	672	–	672	–
P&Q	–	–	14	–
Updating System	–	–	4	4
Coder Tester	–	–	8	3
Total Connections	762	924	787	283

DL: Demand lead DLO: Demand lead odd DLE: Demand lead even CF: Coder free

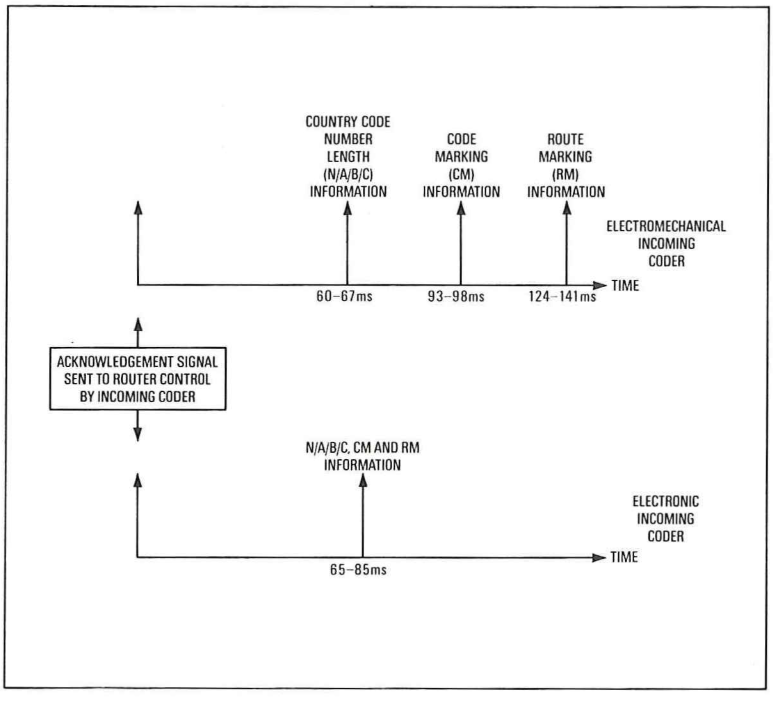
Note: The connections to each updating system are via two serial lines

20 mA signalling convention), one to each of the UDSs.

The revised interconnection arrangements for the EIC have resulted in a reduction of input and output ports on the EIC to a total of 1070, compared with 1686 input and output ports for an EMC (refer to Table 1 for details). Most of the connections to and from the coder tester (CT) are made by tapping onto the highways between the EIC and other functional units; therefore, the CT has little effect on the total number of input and output ports required.

The basic principle of operation of an incoming coder interworking with other functional units is as follows:

Figure 4
Typical timings for output signals on a call attempt resulting in a free outgoing circuit being identified



(*a*) A router control forwards a demand signal to a free incoming coder, and the incoming coder returns an acknowledgement signal if it accepts the demand signal (this allows the marshalling of simultaneous demands).

(*b*) Upon recognition of an acknowledgement signal, a router control, and the register associated at that time, couple to the appropriate incoming coder highways (each router control has access to a 'main' and an 'alternate' incoming coder).

(*c*) The categories of information described earlier in this article are passed to the incoming coder, from the register, together with a register demand signal.

(*d*) The incoming coder analyses the information presented to it, in conjunction with the GO/GR relay information supplied to it, and gives one of the five output categories described earlier.

(*e*) The incoming coder then waits until it receives an instruction from the router control, either to send an output to the equipment monitor (in the case of a call attempt failure), or to initiate the release sequence.

The above basic principle of operation has been retained for the EIC. However, an EMC operates primarily in an asynchronous mode, with relays operating as soon as information is received. The EIC operates synchronously, in accordance with instructions from its central processing unit (CPU), and, hence, the timings of output signals are completely different from those of an EMC. Whereas an EMC gives a three-stage output of information, an EIC gives all of the information at the same instant. Hence, the holding time for an EIC is less than that for an EMC, and this results in an increase in the availability of the incoming coders. Figure 4 shows typical output timing sequences for a call attempt resulting in a free outgoing circuit being identified.

ELECTRONIC INCOMING CODER SYSTEM ARCHITECTURE

Figure 5 shows the interconnection of the functional units of the EIC system. The following criteria were used in choosing the system architecture:

(*a*) As stated earlier in this article, the EIC is a one-for-one replacement for the EMC, so that the basic TXK2 system security could be maintained, with a minimum of changes to other TXK2 functional units.

(*b*) Two independent UDSs, each with their own individual highways to each EIC, are provided for security reasons.

(*c*) Two CTs are provided, one normally serving X EICs and the other Y EICs, in order to retain the separation of X and Y functions in accordance with the security principles of the TXK2 system architecture.

The terminal switch ensures that terminals are connected to the on-line UDS (the exception being the console printers which are permanently connected, one with each UDS, in order to be able to immediately print-out any information pertaining to the internal functioning of the UDS).

The group occupancy distribution rack (GODR) is a new functional unit, and is responsible for distributing the signals from the GO/GR relays of the exchange. The distribution is achieved by the provision of special printed circuit backplanes onto which DIN 41612 connectors are mounted. Plug-in cables are used to distribute the signals from the DIN 41612 connectors on the GODR to the appropriate EICs.

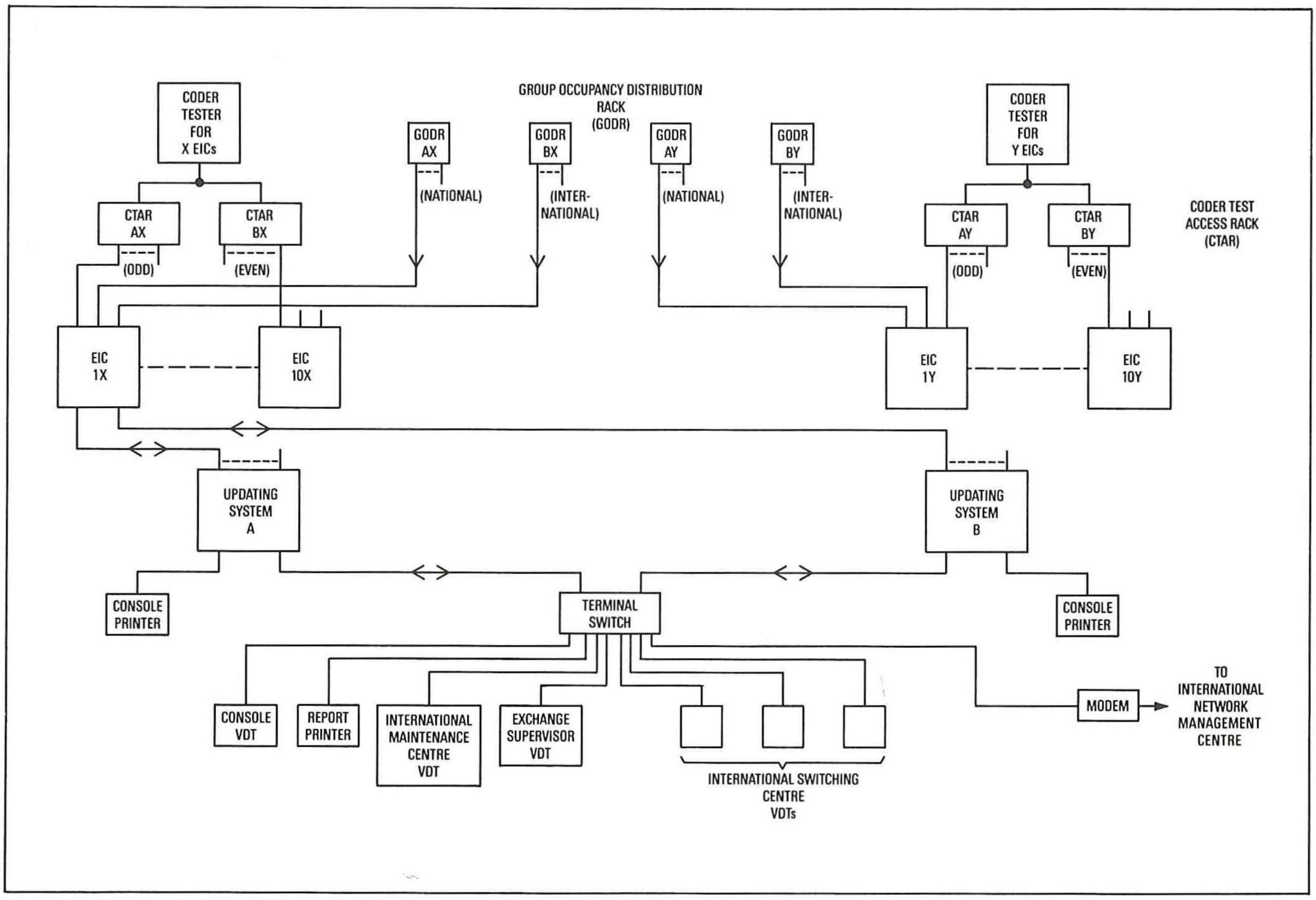
The CTAR and GODR functional units have been split because of their size into AX, BX, AY, and BY sub-units. The CTAR has been split by separating the access equipment to ODD and EVEN numbered EICs, whilst the GODR has been split in accordance with national and international GO/GR engineering route parts.

EQUIPMENT PRACTICE AND PHYSICAL ASPECTS

Each EMC consists of four racks of relays and two coder connect frames (see Figure 6). The 20 EMCs are distributed among other suites of TXK2 equipment on two floors in Mondial House international telephone services centre (ITSC). Each EIC consists of one rack of electronics. All of the EICs, together with the other functional units of the EIC system (excluding some of the terminals), are located centrally, in a purpose-built EIC room in Mondial House ITSC (see Figure 7).

Nineteen-inch Euro-equipment practice racks are used for the EICs, CTs, GODRs

Figure 5
Electronic incoming coder (EIC) system architecture



VDT: Visual display terminal

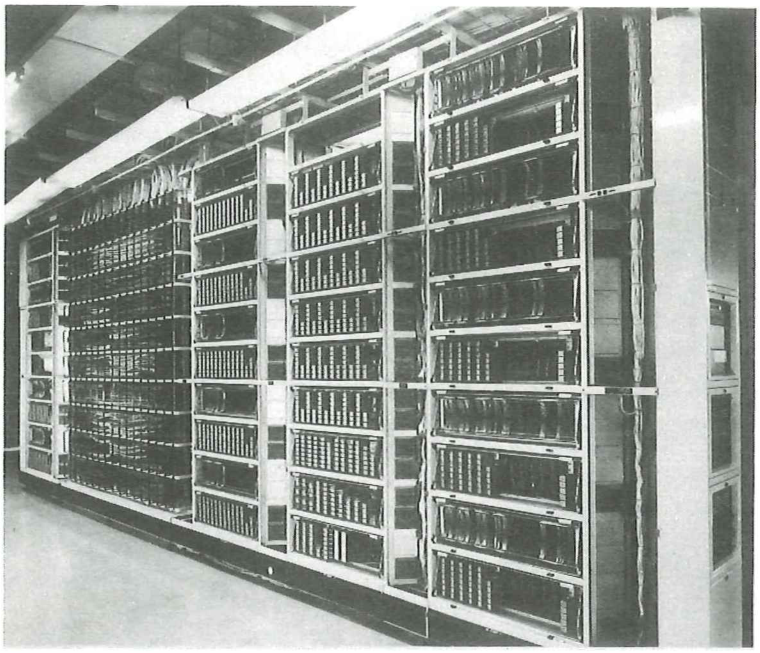


Figure 6—Electromechanical coder (showing the end-of-suite panel on the right-hand end)

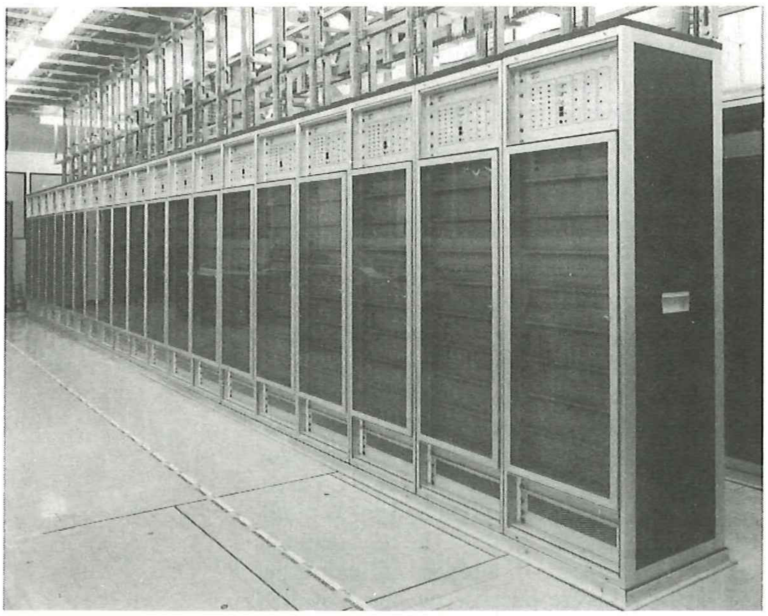


Figure 7
Electronic incoming coder room (showing all 20 EICs)

and for a special rack, the updating system distribution rack, which serves both UDSs. The CTARs are accommodated in TEP-1H equipment practice since relays and electronic components have to be housed, and large connection blocks provided to terminate exchange highways. The UDSs (which are described later in this article) are housed in DEC (1060 mm high) computer cabinets.

DEVELOPMENT ASPECTS

After a detailed feasibility study at the inception of the EIC system project, BTI decided to undertake the development in-house. This decision was made primarily with consideration to the need to carry out extensive testing, followed by installation activities, without Mondial ISC being taken out of service. In addition, because of the limited documentation detailing design parameters for Mondial ISC, it was considered impracticable to write a detailed specification for the interface conditions, to which the EIC system would need to work, in order to place a development contract.

During the feasibility study, it was recognised that, because of the need to minimise development effort, it would be necessary to employ existing designs of microprocessor hardware, and modify them to meet the requirements of the EIC system. Hence, the hardware for the EICs was based upon the BT Research Laboratories (BTRL) Microprocessor Systems Support Services' (MSSS) 8085 CPU, and DEC minicomputers were specified for the UDSs.

After the feasibility study had been completed, the development was undertaken in a number of phases, as indicated below:

(*a*) a detailed paper study of the facilities and functioning of the EMC;

(*b*) a detailed analysis, by carrying out tests on Mondial ISC, of the exact interface conditions with which the EMCs interwork;

(*c*) a detailed study of the method of realising the facilities of the EMC, and of adding the new and enhanced facilities of the EIC system;

(*d*) the development and rigorous testing of the hardware of a prototype EIC;

(*e*) the development and rigorous testing (using purpose-designed software simulators) of the software for the EIC and for the UDS;

(*f*) special development tests with the prototype EIC hardware and software combined, in conjunction with a purpose-designed development version of the coder tester (a microprocessor development system was used with the development version of the coder tester, instead of an IBM PC/XT which is used on the production version);

(*g*) tests carried out at Mondial ISC with the protoype EIC working 'in parallel' with an EMC (the functioning of both coders was monitored by a BTI-designed comparator);

(*h*) special tests with the prototype EIC providing an output into a dummy router control, in order to verify the correct functioning of the EIC output ports;

(*i*) rigorous testing of the protoype EIC running in place of an EMC (the BTI purpose-designed comparator was also used to monitor the performance of the EIC during these tests); and

(*j*) special tests to select specific proprietary items for use on production EICs (for example, checking DC/DC converters for compliance with BT specification BTR2511).

In order to gain the high level of confidence necessary in the equipment designs before

they could be released for production and installation, rigorous testing programs (many of which consisted of simulating millions of call attempts) were carried out at each development phase. The development process was complicated by the need to develop special items of test equipment (as indicated in the above development phases) so that the testing programs could be completed.

A detailed description of the development process is beyond the scope of this article. However, two aspects of special interest are described below.

Operational Parameters for the EIC

As an EIC electronically scans the conditions presented to it via its input ports, it was necessary to define the exact timings to be used for the scanning process. The timings had to be compatible with the operation of the electromechanical functional units with which an EIC has to interwork. In order to determine these timings, tests were done with a 30-channel event recorder monitoring selected highways of an EMC while it was in service. For some tests, two event recorders had to be run in parallel to give 59 channels (one channel on the second event recorder was used for synchronisation purposes). The event recorders used had a paper speed of up to 1 m/s. Extensive monitoring tests were done on ten of the EMCs, followed by a detailed statistical analysis (using 95% and 5% confidence limits) of the event recorder traces that were obtained. The results of the statistical analysis were used to define the timings which were employed for the EIC. The scan software for the EIC automatically monitors signals appearing outside the range determined by the aforementioned timings. Such occurrences cause the appropriate error codes to be incremented, and, thereby, allow the UDS to collect information from all EICs on any potential timing problems.

Testing with the Prototype EIC

Earlier in this article it was mentioned that the prototype EIC was tested in Mondial ISC by running it, firstly, in parallel with an EMC and, secondly, in place of an EMC. In order to do this, a special test configuration, which uses relays, was designed and installed by BTI in Mondial ITSC. Because of the importance of maintaining service during any tests when the prototype EIC was handling 'live' call attempts, the test equipment configuration automatically restored the EMC to service if an EIC-generated alarm condition was detected. Figure 8 shows the test equipment configuration which was installed in Mondial ITSC. The left-hand rack shown in the photograph is the prototype EIC (which incorporates a logic analyser for development testing purposes), and the other rack contains the following items:

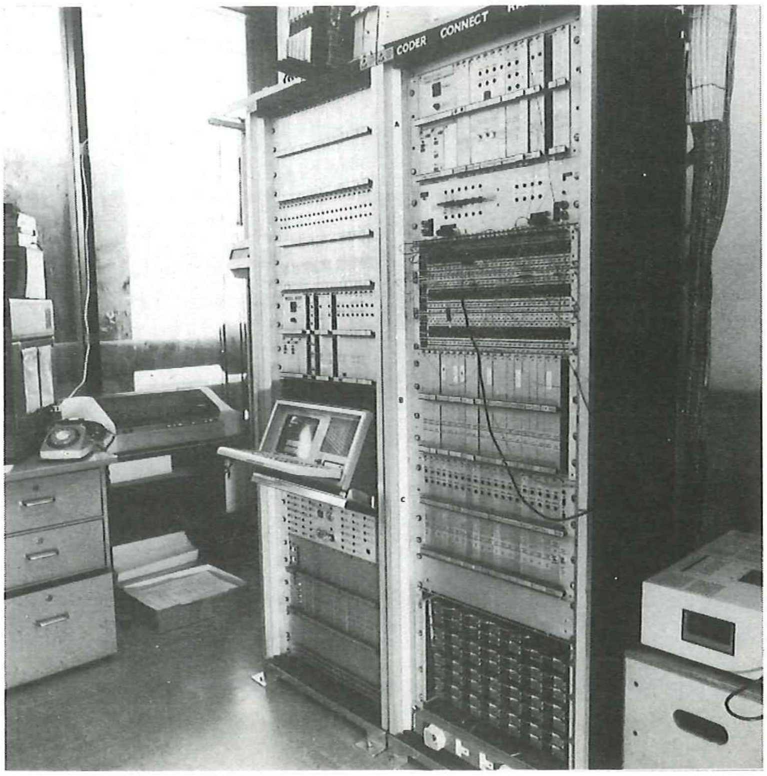


Figure 8
Prototype electronic incoming coder and associated development equipment

(*a*) the access relays which control the test equipment configuration;

(*b*) the electronic comparator (for monitoring the performance of both the EMC and EIC during parallel working tests, and of the EIC during 'live' tests); and

(*c*) a test jack frame for monitoring specific highway conditions.

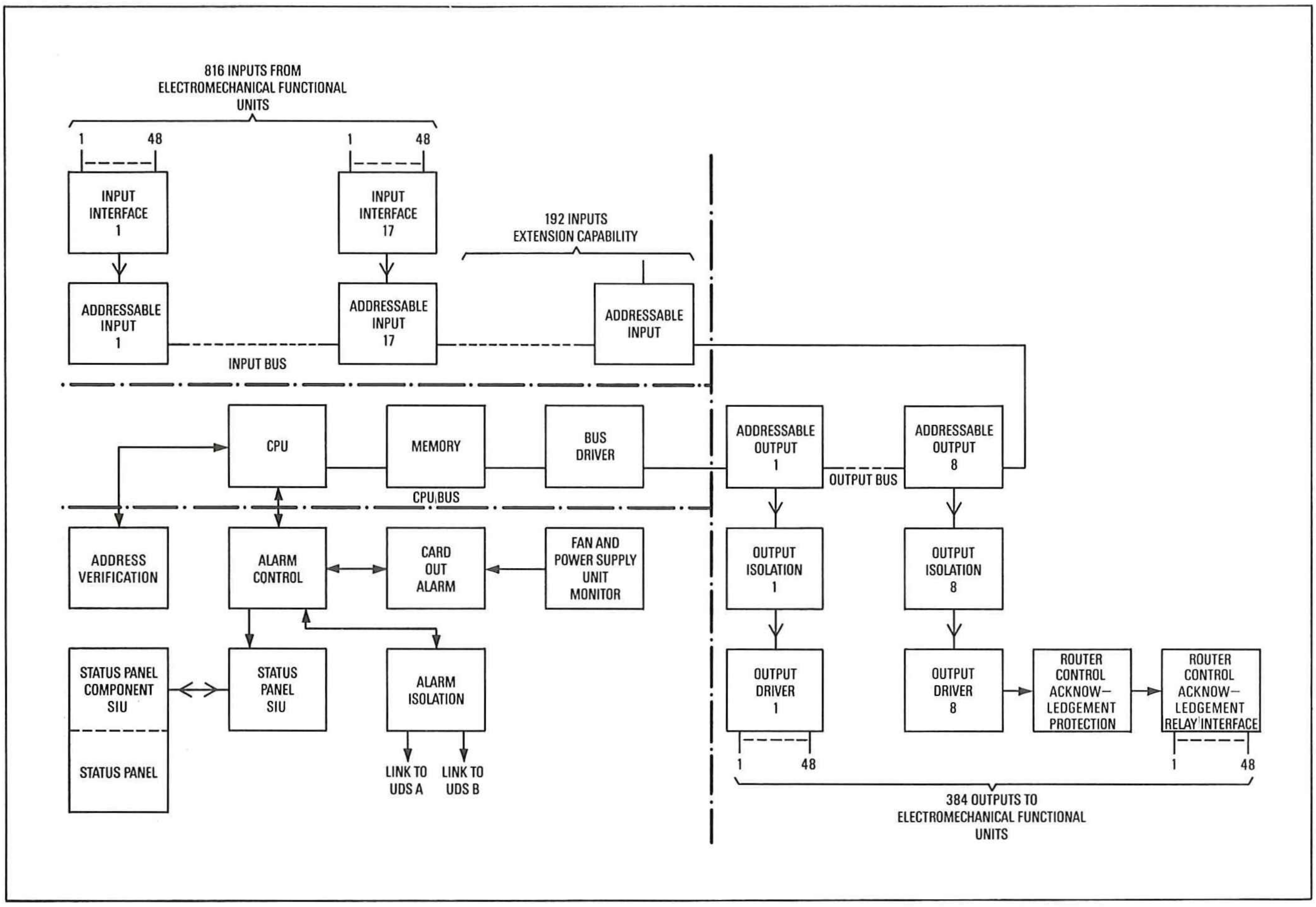
OVERVIEW OF THE EIC

Hardware for the EIC

The choice of the BTRL MSSS 8085 CPU and memory slide-in-units (SIUs) as the basis for the hardware dictated that double-sized Euro-card equipment practice would be used. In practice, the MSSS SIUs had to be modified slightly in order to meet the requirements of the EIC system. In addition, fifteen other types of SIU were purpose designed by BTI for the EIC hardware. Each EIC is housed in a 19-inch Euro-equipment practice rack equipped with a transparent front door, and a metal rear door. The majority of the rack wiring is done by plug-to-plug ribbon cabling. A status panel and rack cooling fans are provided on each EIC rack. The hardware of an EIC can be classified into three categories, namely:

(*a*) the microprocessor unit, consisting of CPU, memory and bus driver SIUs;

(*b*) the interface circuitry, consisting of input interface, addressable input, addressable output, output isolation, output driver, router control acknowledgement protection, and router control acknowledgement relay interface SIUs; and



UDS: Updating system CPU: Central processing unit SIU: Slide-in-unit

Figure 9
Block diagram of electronic incoming coder hardware

(*c*) ancillary circuitry, consisting of equipment providing maintenance controls, maintenance displays, and hardware alarms.

The interconnection of the above categories of hardware is shown in Figure 9. Because of the large number of input and output ports required to connect the EIC with other functional units, a separate input/output (I/O) bus, interconnected with the CPU bus via a bus driver SIU, has been provided. All buses have been provided by the use of double-sided printed-circuit board (PCB) backplanes. Two different methods of bus termination have been used: a lumped terminator for the CPU bus, and a distributed terminator for the I/O bus. In order to protect the electronics of the EIC, PO40 opto-couplers have been provided on all ports interfacing with other functional units. The 'heart' of an EIC is an INTEL 8085A 8 bit microprocessor, which is synchronised by a 4 MHz crystal. Direct I/O working techniques are used, and less than 64 kbytes of memory have been used. In all there are 74 SIUs accommodated on each EIC (see Figure 10) rack, plus some special component cards.

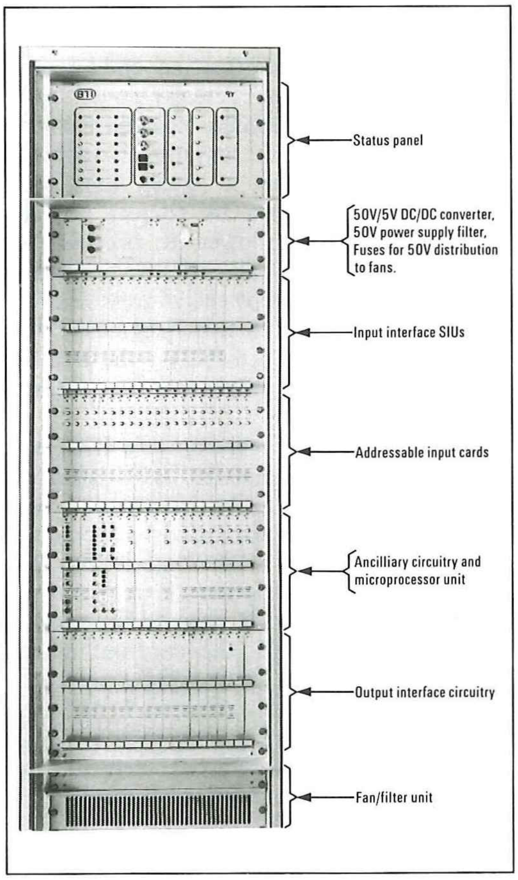


Figure 10—Electronic incoming coder rack

Software for the EIC

Most of the software for the EIC has been written in the PLM high-level language, with

the remainder written in 8085 assembly language. The software has been arranged in three suites, namely:

(*a*) scan suite,
(*b*) call processing suite, and
(*c*) UDS service suite.

The scan suite is responsible for the following functions:

(*a*) the intialisation process,
(*b*) scanning for router control demands,
(*c*) the release of the router control, and
(*d*) the housekeeping routine.

The call processing suite is the largest of the three suites, and consists of 14 kbytes of code, together with 34 kbytes of data held in 41 tables. The up-dating service suite, which consists of 2·8 kbytes of code, is responsible for controlling the protocol used on the links between the EICs and the two UDSs. The link protocol is not based upon any of the standard serial link communication protocols, but was specially designed by BTI to provide a secure communication within the memory constrained environment of the EIC.

Special Features of an EIC

Each addressable input and addressable output SIU responds to a specific range of addresses (which have been preset by dual in-line (DIL) switches on the SIU) that it receives on the address bus. Hence, if one of the SIUs was inserted in an incorrect position within the EIC rack, it could respond to its correct address, but it would be associated with the wrong I/O information; and a failure to process call attempts correctly would result. To circumvent this problem, the address verification SIU works in conjunction with the initialisation software to check that each addressable SIU is in its correct position before the EIC is allowed to process call attempts. Failure of the address verification procedure is indicated by the address verification SIU displaying (on two 7-segment light-emitting diode (LED) displays) the number of the SIU on which failure was first encountered.

If an SIU is removed from the EIC rack after the EIC has completed its initialisation process, then there is a risk that any data held on the SIU will be lost, or the correct sequence of events interrupted. Once data is lost, it is essential that the equipment is re-initialised before any further call processing is done. Hence, a special SIU, the card-out alarm, detects the removal of any SIU from the rack, and automatically prevents further call processing until the initialisation process has been satisfactorily carried out. The card-out alarm operates by monitoring all of the SIUs on an EIC rack for lack of a +5 V power feed. Hence, failure of a fuse mounted within a SIU and failure in the rack wiring for power distribution are also monitored.

The card-out alarm SIU periodically scans all of the SIUs on the EIC rack and displays (on two 7-segment LED displays) the number of the first SIU scanned that failed the test conditions.

Selected EIC outputs feeding the router control and register highways are fed back into the EIC. This allows the EIC software to check that:

(*a*) the selected outputs are functioning correctly; and

(*b*) whether the register and router control have fully decoupled from the incoming coder highways during the release sequence.

The latter function provides a more accurate and faster check of the correct release of a register and router control from the incoming coder highways than a simple release-guard time-out. The technique is based upon the EIC observing when the bias conditions which 'backfeed' from a register and router control, via the incoming coder highways, are removed.

OVERVIEW OF THE UDS

Each UDS consists of a DEC PDP11/23-Plus minicomputer equipped with a dual 10·4 Mbyte disc drive with integral controllers. The DEC RSX11M operating system has been used, and the applications software has been developed, by BTI, using Coral 66 and PDP11 Macro program languages. Each UDS has a link to each EIC. The links use the 20 mA convention and operate at 9·6 kbit/s. The terminal switch allows all of the terminals to be connected to the on-line UDS, by switching the RS232C highways appropriately. In addition, the terminal switch allows the on-line UDS to be connected, via a dedicated RS232C highway, into a BTI-designed alarm interface unit. The alarm interface unit can decode a range of ASCII characters it receives over the dedicated highway, into different alarm output conditions for feeding into the exchange alarm scheme.

The UDS performs the following functions:

(*a*) it automatically (or on command) updates a specific EIC or all EICs, with the latest routing information held on disc;

(*b*) periodically, it automatically polls each EIC and receives maintenance block files (which contain error codes and other status information) which are then analysed;

(*c*) it can service the needs of the international network management centre (INMC) (via the INMC VDT) for temporary reconfigurations of the routing information; and

(*d*) it provides the VDTs for the exchanges's supervising officer, international maintenance centre and ISC with the appropriate information on the status of the system or of selected routing information for maintenance or operational requirements.

The EIC system is controlled via the console

VDT, with information on the performance of the system being provided via the report printer (RP).

For security reasons, the two discs associated with the on-line UDS contain identical information (information stored on one disc is automatically copied onto the other disc). The types of information stored on a disc are:

(*a*) the latest master call routing and barring information;

(*b*) any pre-defined temporary changes to the routing information (these are held in readiness for immediate execution by the INMC if an emergency arises);

(*c*) details of any temporary changes in force, together with the original routing information for re-instatement once the need for the temporary change has ceased; and

(*d*) a cumulative record of certain parameters of the maintenance block files.

NEW AND ENHANCED OPERATIONAL FACILITIES

Because of the flexibility provided by the EIC software, and the capability to partially or wholly re-configure the EIC data by VDT command, it has been possible to provide a number of facilities which are additional to those available on the EMCs. Two of the new facilities are described in outline below.

Interworking with the INMC

The INMC VDT can apply the following temporary changes:

(*a*) temporary alternative routings;

(*b*) route blocking;

(*c*) percentage reduction of calls;

(*d*) inhibiting call attempts by class; and

(*e*) associating special recorded announcements to either a specific route, destination, or route destination.

Call Barring

Each incoming circuit on Mondial ISC is allocated a P&Q identification code. This code is determined by the position of the circuit on the exchange switchblock. The original function of this code was to allow an incoming circuit to be uniquely identified to the IATAE for international accounting purposes. The EIC system has added a meaning to the P&Q identification code by also using it for some special call barring purposes. As each EIC has access to the P&Q highway from the circuits that it serves, it is possible for an EIC to hold a look-up table containing barring information on a per circuit basis. A range of special barring facilities has been provided by this means. For instance, it is possible to bar different combinations of terminal and transit calls in conjunction with the class of these calls (for example, operator- or customer-originated calls). The look-up table in each EIC is sent to the EIC, by the UDS, in the same manner as other call routing information; this ensures full flexibility in the allocation of barrings.

An enhanced range of call barring facilities for traffic outgoing from the exchange is also available. Outgoing call barring can be applied at either route, destination or route destination level.

MAINTENANCE FACILITIES

Throughout the development of the EIC system, special attention was paid to the provision of suitable maintenance facilities. A range of facilities has been provided, which not only allows close monitoring of the EIC system, but also some monitoring of the electromechanical functional units with which the EIC system has to interwork. For instance, certain types of fault within individual registers have been identified by the EIC system.

The maintenance facilities of the EIC system can be categorised as follows:

(*a*) automatic checks performed during the initialisation of an EIC;

(*b*) thirteen different types of automatic checks performed during normal service of an EIC;

(*c*) maintenance block files sent periodically from EICs to the UDS;

(*d*) automatic analysis of maintenance block files by the UDS;

(*e*) manual maintenance controls and maintenance displays (on the EIC status panel);

(*f*) special maintenance commands, available via the console VDT, for checking EICs;

(*g*) the CT; and

(*h*) maintenance facilities for the UDS.

A detailed description of the maintenance facilities of the EIC system is beyond the scope of this article. However, four facilities of special interest are described below.

Scan-in-Idle

This facility enables an EIC to monitor some of its own input ports. After an EIC has accepted a demand signal from a router control, there is a quiescent period of about 12 ms during which no signals should be received on the register or router control highways. Hence, at that time, all relevant EIC input ports should be in the INACTIVE state. The EIC software scans the ports and logs any that are in the ACTIVE state. A special algorithm within the EIC software sets the appropriate fault flags, which are transmitted to the UDS via the maintenance block files for further analysis. A fault detected in this way can be due to either:

(*a*) a hardware fault on an EIC input port, or

(*b*) a fault on a highway feeding the EIC.

Signal Received Check Flags

Signal received check flags complement the scan-in-idle facility. They are provided for each of the input ports covered by the scan-in-idle facility. Each time that an EIC observes (during the processing of a call attempt) that an input port is in the ACTIVE state, it sets the corresponding *signal received* check flag. These check flags, which are sent in the maintenance block files to the UDS, thus allow the detection of input ports or input highways which have failed, and remain in the INACTIVE state. However, because certain input ports are used infrequently during call attempts, the UDS analyses, on a per EIC basis, the cumulative result of a number of pollings of maintenance block files before a maintenance printout is given.

GO Mapping

It can be seen from Table 1 that 85% of the input ports of an EIC serve the GO/GR relay feeds. As the GO/GR relays operate asynchronously, there is not an instant of time when an EIC knows that a specific input port should be in a specific state. Therefore, in order to monitor the performance of the GO/GR relay input ports, a GO mapping technique is used instead of a scan-in-idle method.

An EIC scans its GO/GR relay input ports immediately prior to attempting to process a call attempt (this ensures that the latest information is used). The information gathered is stored in two test blocks as well as being used to process the call attempt. The information is combined with that already in the test blocks as follows:

(*a*) ORED with test block 1; and
(*b*) COMPLEMENTED with test block 2.

A dedicated area within the maintenance block files is allocated to the test blocks. Therefore, the UDS can store information received in the maintenance block files on successive pollings, and then perform a detailed analysis on a per-EIC basis. Test block 1 provides information on those GO/GR relay feeds which have been in the ACTIVE state, and test block 2 indicates those which have been in the INACTIVE state.

Coder Tester (CT)

Each of the two CTs accesses the EICs with which it is associated via its own CTARs. The CTARs contain a switch matrix consisting of type 23 relays, which are under the direct control of its associated CT. The CT is capable of monitoring the performance of the switch matrix to ensure that multiple connections to more than one EIC at a given instant in time are not made.

A CT consists of two parts: a CT rack, which is almost identical to an EIC, and an IBM PC/XT computer.

The IBM PC/XT computer, which has an integral 10 Mbyte Winchester disc drive, is connected to the CT rack via an RS232C highway. All of the analysis software, and software for the screen formats, are contained within the IBM PC/XT, which also provides the human interface via its integral VDT.

A CT has three basic modes of operation:

(*a*) the monitor mode;
(*b*) the I/O port hardware test mode; and
(*c*) a simulated call attempt mode.

A CT interworks with an EIC in a similar fashion to the method used by router controls. The CT is effectively the '21st router control' served by an EIC and, therefore, it is not necessary to manually busy an EIC when it is interworking with a CT.

The monitor mode allows a CT to observe the interworking between a specific EIC and other functional units during the processing of call attempts. It is possible to specify the exact type of call to be monitored, with selection on any highway parameter, or combination of parameters. The results of the monitoring can be stored on the Winchester disc for subsequent analysis.

MANUFACTURING ASPECTS

The artwork for the 27 different types of BTI-designed PCBs was produced by the BTI Drawing Office. The manufacture of the BTI-designed PCBs, and the associated assembly work for SIUs and various types of backplane, was put out to contract. As a high failure rate of SIUs could jeopardise the continuity of service provided by Mondial ISC, a two-stage testing procedure was applied to most types of SIU, as follows:

(*a*) testing by the contractor using automatic test equipment (ATE); and
(*b*) testing by the contractor using a BTI-designed test crate to check the interworking with other types of SIU, and to identify any problems not detected by the ATE.

Automatic testing methods were imperative in order to deal successfully with the large numbers of some types of SIUs. The five highest-penetration SIUs were manufactured in the following quantities:

Input interface SIUs	400
Addressable input SIUs	490
Addressable output SIUs	190
Output isolation SIUs	190
Output driver SIUs	190

The second stage of testing proved to be very valuable, since the ATE did not provide full functional testing of an SIU.

The assembly and associated wiring of all of the racks for the EIC system were carried out by BTI personnel. Rack wiring was tested manually at each stage of assembly.

INSTALLATION ASPECTS

The installation programme for the EIC system was based upon the following criteria:

(*a*) the need to maintain service on Mondial ISC without any disruptions;

(*b*) the need to disconnect fully the EMCs (in order to save power and to reduce the maintenance liability);

(*c*) the need to be able to revert to the EMCs during the early part of the installation programme should the need arise; and

(*d*) the need to ensure that the installation could be done in an expeditious manner.

The above criteria were taken into account at the development stage, by making the maximum use of pre-formed plug-to-plug cabling and modular construction methods for equipment. In addition, all of the exchange highways were pre-cabled to the EIC room, so that the EICs could be commissioned rapidly in a phased manner. The CTs with their monitor mode capability of observing and recording the conditions on the exchange highways connected to EICs played a significant part in the commissioning activities.

CONCLUSIONS

The EIC system which has been installed within Mondial ISC provides the electromechanical exchange with stored program control. The main advantage of the EIC system is that it allows the call routing data of the exchange to be reconfigured rapidly, via VDT commands, to meet BTI's operational requirements. In addition, a number of enhanced operational and maintenance facilities are provided by the EIC system. Some of the enhanced maintenance facilities allow close monitoring of certain aspects of the performance of TXK2 register and router control functional units in a manner that was not possible prior to the introduction of the EIC system.

Thus Mondial ISC is better able to serve the needs of BTI.

ACKNOWLEDGEMENTS

The authors would like to thank the other members of the EIC system development team, and several other colleagues in BT, for their assistance throughout the project.

Biographies

David Johnson is Head of a Systems Development Group in BTI's Implementation and Design Division. He joined BT, via the open competition, in 1969, after graduating from London University with an honours degree in Electrical Engineering. He worked on the development of TXE4 and, in 1976, commenced work on the development support for TXK5 ISCs. In 1979, he was promoted to Head of Group dealing with TXK2 and TXK5 ISC development support. He has been the development manager in charge of the EIC system project since its inception. He currently deals with the post-contract technical aspects of a new digital international switching centre.

Bill Bailey joined BT as an apprentice in 1965 and worked on transmission maintenance until being promoted to level 1 in 1977. He worked on the development support for TXK2 ISCs, specialising in microprocessor based projects. He has been involved with the EIC system project since its inception, and has been responsible for hardware development, interface software development, testing and commissioning of the equipment. He was temporarily promoted to Head of Group on the EIC project during the final development, testing and commissioning stages. He was recently given substantive promotion to Head of Group, and currently works for BT Applied Technology where he is the project manager for customer administration systems.

ALE—Testing to the Customer Interface

J. F. MARSHALL, M.SC., C.ENG., M.I.E.E., G. H. HORNSBY, and G. R. PRICE†

UDC 621.395.63 : 621.395.12.001.4

British Telecom (BT) is currently introducing remote testing capabilities into its extensive analogue private circuit network in order to improve the efficiency of fault localisation and so reduce overall repair times. This is being accomplished by the development and installation of automatic loopback equipment (ALE) at customers' premises which will enable testing staff to prove whether a fault lies in the local network or beyond the interface with the customer. Benefits include faster testing of circuits without the need for manual intervention by the customer, or a visiting BT engineer attending on call out, and reduced circuit down times.

INTRODUCTION

In its task to further improve maintenance efficiency on private circuits, British Telecom (BT) has been developing automated methods of localising faults when they occur so as to reduce circuit down times. A previous article* on remote access test equipment systems (RATES) described how this was achieved in the network as a whole. Of significant interest is the need to resolve faults to either the network or to the terminal equipment side of the customer's interface. This is of particular importance in those cases where the equipment is customer owned and responsibility for fault repair needs to be quickly established. Even where customer equipment is leased from BT, it is still beneficial for BT to correctly identify which repair staff should be dispatched to the fault and so minimise abortive visits to the customer's premises. Automatic loopback equipment (ALE) has been specifically developed to meet this need. Whilst ALE provides benefits in its own right, its full strength is achieved when used in conjunction with RATES to effect end-to-end remote testing of private circuits.

ALE CONCEPT

The primary service provided by ALE is to facilitate remote testing to the customer's interface without the need for assistance either from the customer or through the dispatch of an engineer. This is achieved by providing a remotely operated loopback (in the case of 4-wire-customer-presented circuits) or a tone back (in the case of 2-wire-customer-presented circuits) at the network interface to the customer, and so enable testing personnel to determine if a fault exists in BT's network up to the network interface (see Figures 1 and 2). The remote operation of both devices is achieved by a command signal sent from a maintenance test point and communicated to the ALE via the private circuit.

In the case of 4-wire circuits, this loop conforms with CCITT‡ Recommendation V.54 (Loop Test Devices For Modems). The ALE provides externally, loop number 4, which is an analogue-type loop whose importance is enhanced by the fact that it is provided at the circuit interface point.

Essential Features

In order to achieve reliable and useful testing, together with ease of installation and operation, the ALE has been designed to meet the following requirements:

(*a*) If BT's network is fault free, the ALE must always operate regardless of any fault conditions caused by the customer's equipment.

(*b*) It must be transparent to the workings of BT's network and any attached equipment.

(*c*) It must possess a high degree of security against false operation.

(*d*) It must remain reliable despite infrequent operation so that testing personnel have a high degree of confidence that, if the ALE does not operate, it is the line that is faulty. (Frequency of operation may be only once or twice every two years.)

(*e*) It must be capable of deriving power both from the line DC wetting current and from local power supplies.

(*f*) It must be compatible with new test methods and equipment; for example, RATES.

(*g*) It must be easy to install.

(*h*) It must fail safe if power is lost.

(*i*) It must be capable of being fitted to existing circuits without the need to readjust line attenuators and equalisers.

Benefits of ALE

Several important benefits are anticipated from the introduction of ALE on private circuits. The main ones being:

† Trunk Network Systems Engineering Division, British Telecom Inland Communications

* MARSHALL, J. F., GALLAGHER, R. M., and RATTI, A. RATES: An Aid to Private Circuit Testing. *Br. Telecommun. Eng.*, Jan. 1986, **4**, p. 188.

‡ CCITT—International Telegraph and Telephone Consultative Committee

Figure 1
Example of 4-wire-presented circuit showing the Test Unit 22B operated and returning the command signal for measurement

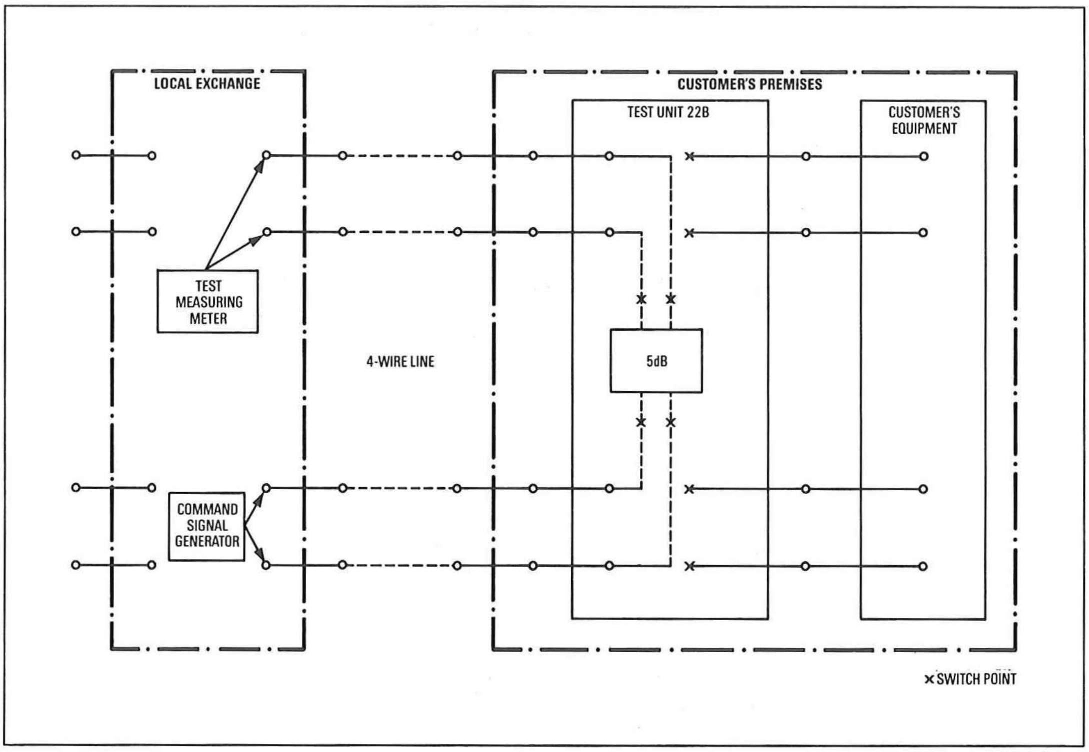
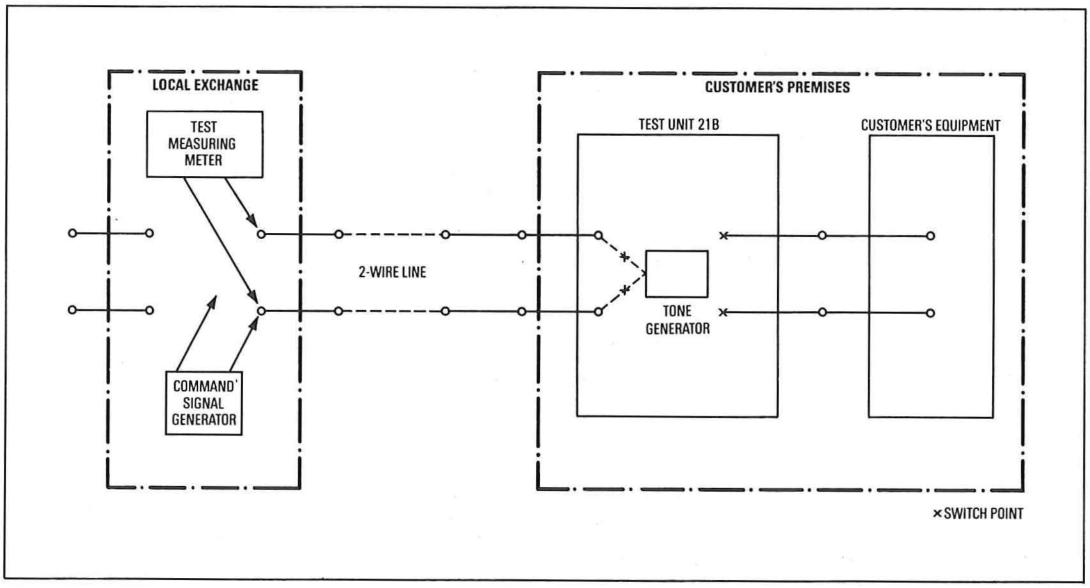


Figure 2
Example of 2-wire-presented circuit showing the Test Unit 21B operated and returning a tone for measurement



(*a*) unassisted end-to-end testing by centralised maintenance personnel,

(*b*) reduced testing time,

(*c*) more effective utilisation of mobile maintenance personnel,

(*d*) reduction in circuit down time, and

(*e*) minimisation in the number of visits to customers' premises on circuit provision.

OPERATION

To achieve security against misoperation of the ALE, the relationship between the application of the command signal and the operate, hold and release sequences is of critical importance.

Application of the command signal causes the ALE to operate, and once operated, it remains held in this state indefinitely. A second application of the command signal allows the ALE to release. Similarly, a third application causes reoperation etc. To guard the ALE against an unintended change of state, a 2–3 s dead period prevents immediate activation from one state to the other. This mode of working is known as the LATCH mode. On the 2-wire ALE, an alternative mode of working is also available, known as the TIME-OUT mode, where the ALE can be configured to release 60 s after operation.

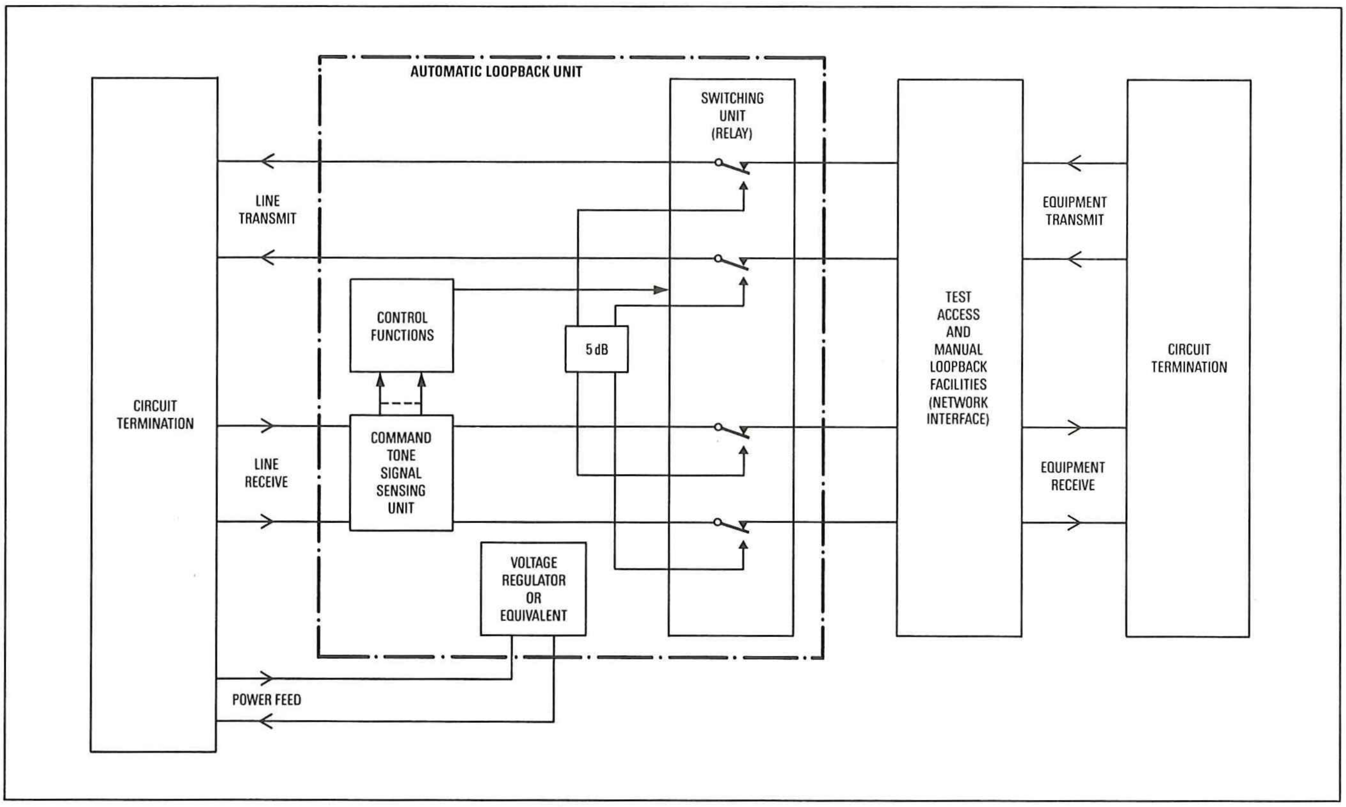
The main functional parts of the ALE are shown in the block diagrams given in Figure 3, for the 4-wire ALE (Test Unit 22B), and Figure 4, for the 2-wire ALE (Test Unit 21B).

Circuit termination is provided by means of insulation displacement connectors. Test access is available at the customer's interface. The 4-wire ALE has a manual looping facility which can loop, via a 5 dB attenuator, both to line and equipment. This manual facility is available to customers, who thus retain the ability to undertake their own testing, a facility required by major customers with their own telecommunications personnel.

A voltage regulator takes power from the line or a local supply and regulates it to give an output suitable for driving logic circuitry independent of the input voltage, which may vary between 50 V to less than 20 V when the ALE is line powered.

The command-signal sensing unit monitors the line receive path for a command signal

Figure 3
Block diagram of the 4-wire ALE (Test Unit 22B)



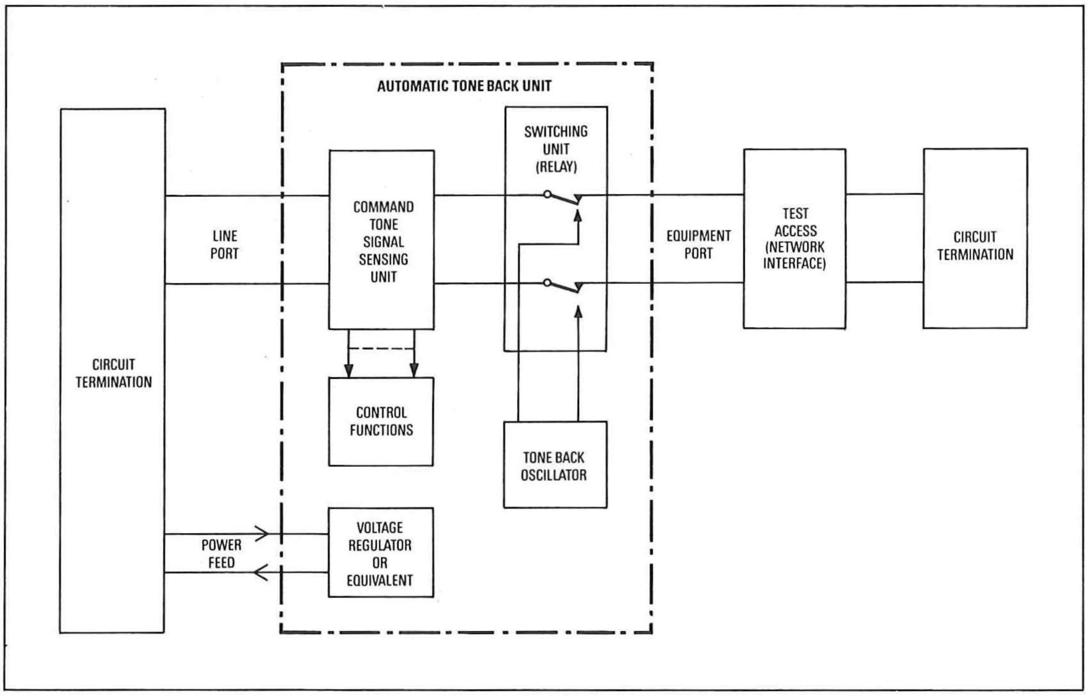


Figure 4
Block diagram of the 2-wire ALE (Test Unit 21B)

and is effectively transparent to other line signals. The sensing unit is designed to enable the ALE to operate irrespective of any conditions present on the customer's side of the interface. This is achieved by circuitry which can react to either command-signal current or voltage, or a combination of both, and so obviate the effect of short circuit to open circuit conditions on the customer's side of the interface.

Circuitry in the control function block checks the validity of the command signal before instructing the switching unit to operate; it also controls the operate, release and guard sequences.

A BT Type 50 relay is used for switching. This is a very sensitive double-pole change-over relay suitable for switching low-level signals where DC wetting cannot be provided.

Protection

Fast-acting semiconductor devices are fitted to the ALE and provide protection against spurious line signals up to 1·5 kV. Where voltage surges of a greater magnitude are expected to occur, gas discharge tubes are fitted externally in the normal manner.

Command Signal/Receiver Characteristics

The command signal is a sinusoidal single frequency of bandwidth ±28 Hz within the audio spectrum and this signal must be maintained uninterrupted for a minimum period of 3 s. Logic circuitry in the control function block verifies that the command signal is of the correct frequency and duration, and that the level is within the dynamic range of the receiver.

The dynamic range of the ALE receiver has been calculated so that, allowing for the overall loss of the circuit, for the range of Engineering Performance Specifications (EPSs), together with the allowable spread in insertion loss at the command signal frequency, the ALE will always operate to a −5 dBm0 command signal, provided that the circuit is within its normal operating limits.

MECHANICAL FEATURES

The ALE is based on the Test Unit 4B† and is fitted into 62-type equipment practice racks and enclosures; that is, Equipment Audio 1002A, Cases 200A, 228A and 229A. Figures 5 and 6 shows Test Units 22B Mk. 1 and 21B Mk. 1, respectively. They each consist of two printed-wiring boards mounted one upon the other and are 12 modules wide. Wiring connections use standard insulation displacement connectors. Electrostatic precautions must be taken when they are handled.

† The Test Unit 4B is the forerunner of automatic loopback devices and is operated manually by the customer.

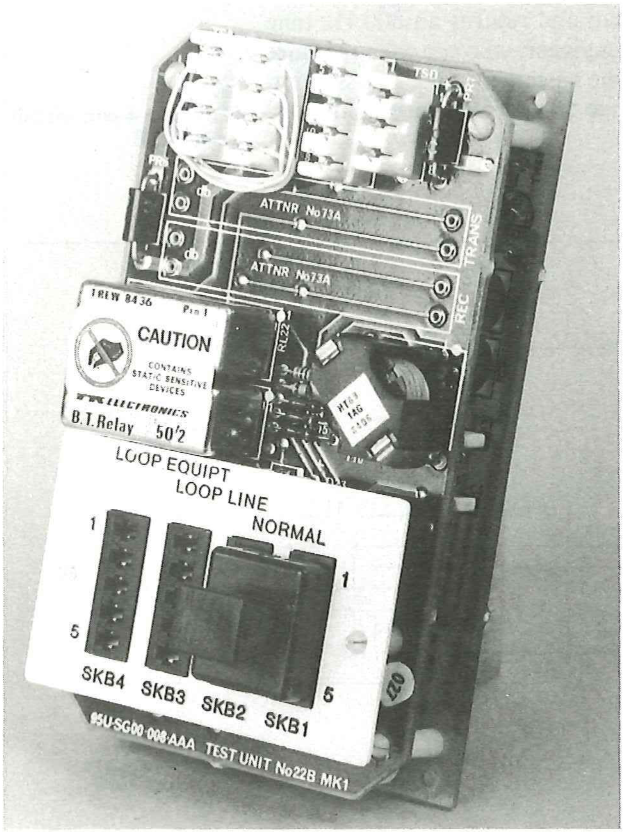


Figure 5—Test Unit 22B Mk. 1

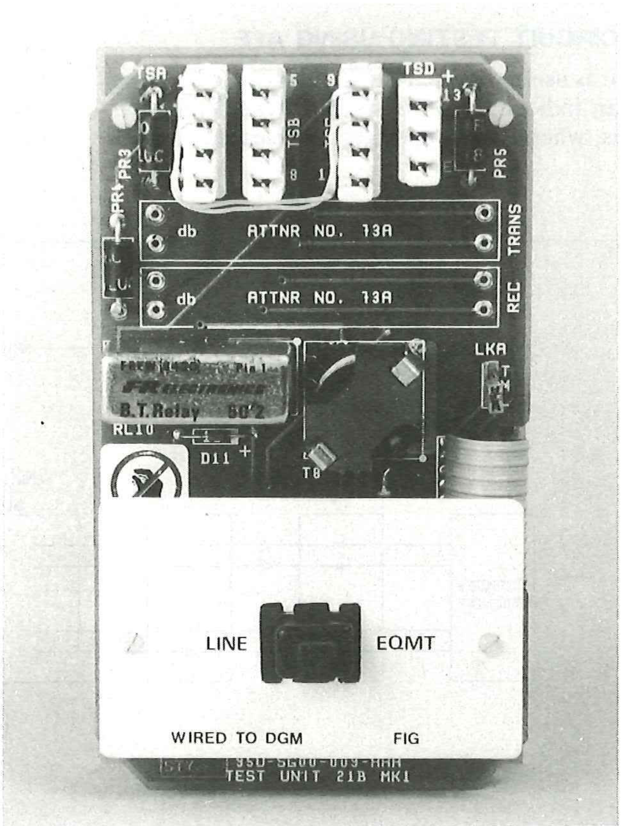


Figure 6—Test Unit 21B Mk. 1

More recent developments in equipment practice have allowed the ALE to be fitted into the Kit 620.

PERFORMANCE

The performance of the ALE has been specified in three main areas.

Transparency

The ALE must be transparent so that the ALE can be fitted into an existing circuit without the need for any transmission re-alignment. The main parameters specified to achieve this are as follows:

PARAMETER	LIMIT
Insertion Loss	<0·2 dB
Return Loss	>25 dB
Group Delay Distortion	<10 μs
Absolute Delay	<10 μs
Crosstalk	>90 dBm
Noise	<−80 dBm

Operation in the Presence of Fault Conditions

The ALE is designed to operate in the presence of open circuit, short circuit, noise and interference signals appearing on the terminals of the customer interface.

Operate Bandwidth

The operate bandwidth is closely specified in order to achieve security against false operation.

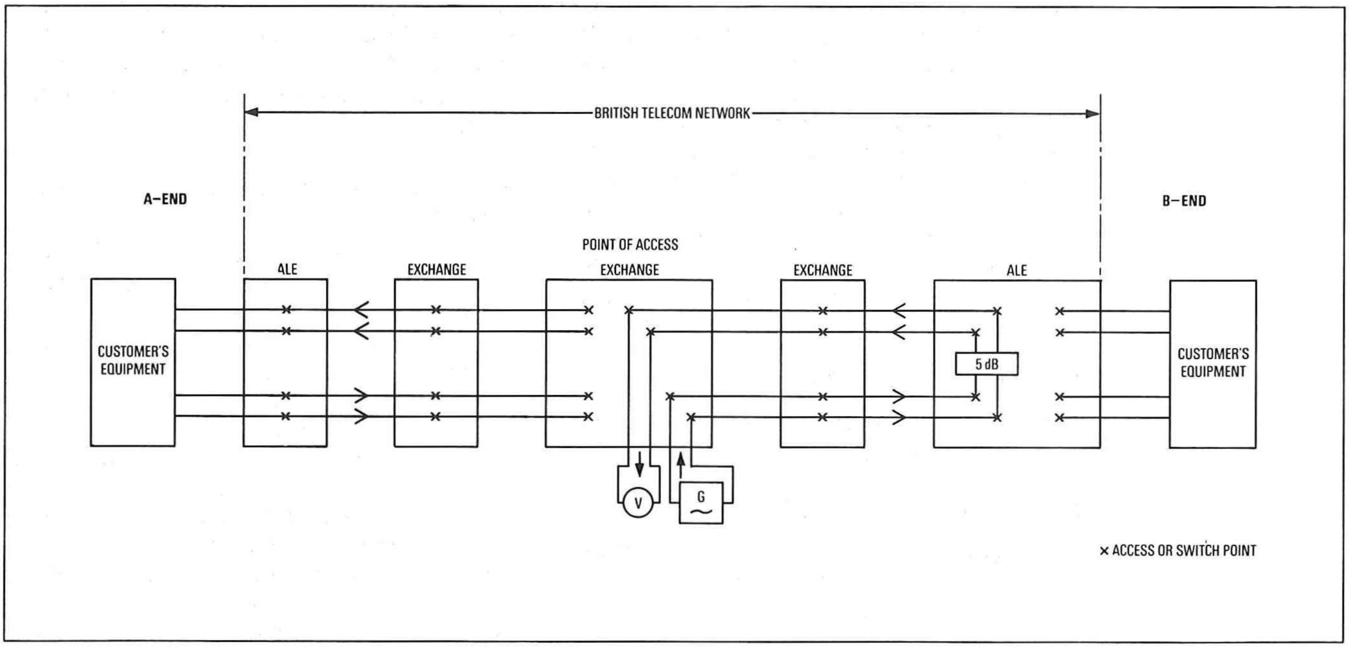
CIRCUIT TESTING USING ALE

It is useful for the testing engineer to be given an indication of the status of the ALE; that is, whether it is operated or released. This is achieved by measuring or by listening.

Consider Figure 7, which shows a 4-wire customer-presented private circuit with testing taking place towards the B-end by using a Test Unit 22B. Prior to disconnection in both the transmit and receive directions, the circuit will have been monitored to establish that the circuit was not in use. An oscillator is connected to the transmit path to generate the command signal and a level measuring set connected to the receive path. When the ALE operates, the line transmit and receive paths are looped via a level-correcting 5 dB attenuator and the customer's terminals are disconnected. Thus any conditions present on the customer's equipment cannot affect testing on line. Provided there is continuity around the loop, the command signal is returned and can be monitored on the receive pair. This provides the testing engineer with a positive indication that the ALE has operated. The signal frequency can then be changed and 'around the loop' measurements of insertion loss made across the circuit bandwidth. To undertake this test, the testing engineer needs to know the expected loss around the loop at the reference frequency 800 Hz and the allowed spread over the bandwidth. Application of a second command signal releases the ALE. Again by monitoring the receive path, it can be confirmed that the circuit has been restored to normal.

Figure 8 shows a 2-wire customer-presented circuit with testing taking place towards the B-end by using a Test Unit 21B. In this configuration, the ALE responds to the command signal and returns an 800 Hz tone to the testing engineer, who can then measure the loss from the customer to the access point, and hence judge the performance of the circuit.

Figure 7
Testing a 4-wire circuit using ALE



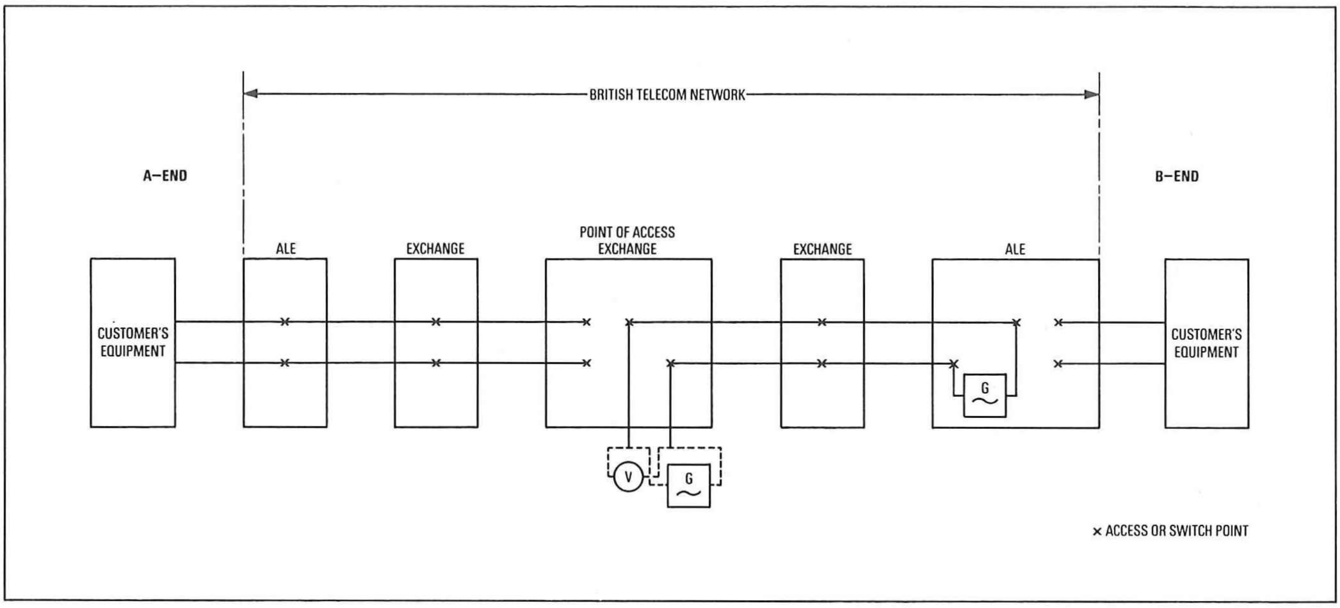


Figure 8
Testing a 2-wire circuit using ALE

The principle of these methods of testing is not new. For instance, the use of a remote loop provided with the assistance of the customer has been in use for many years. This procedure involved co-operation with the customer over the telephone, and required the customer to move a link on a test unit while testing was undertaken. This suffered from a number of drawbacks. The customer often had difficulty in locating the test unit and, when testing was undertaken, there was always a degree of uncertainty as to whether the customer was following the instructions correctly. Also, only very limited testing could be undertaken on 2-wire-presented circuits.

PROVISION OF PRIVATE CIRCUITS

In many instances, private circuits are not provided as end-to-end circuits in a single operation; often, on long circuits, separate sections are provided at different times. When all sections are completed, the overall circuit should be working within prescribed transmission limits. ALEs can be of assistance in allowing the circuit to be tested end to end without further visits to the customer's premises. An additional use, when there is a significant delay in the completion of one of the sections, could be to guard the line by operating the ALE and leaving it in LATCHED mode with a test tone on line to indicate that the cable pairs have been allocated to a circuit.

FUTURE DEVELOPMENTS

A number of future developments are in hand or under consideration:

Second Generation ALE

A second generation of ALE is under development and this will be incorporated in the latest family of line test units (LTUs) being developed by BT.

Addressable ALE

There appear to be two main situations where addressable ALE is likely to prove advantageous: on multi-point circuits; and on long lines, particularly where these are routed through unattended exchanges.

In the first case, addressable ALE could be used on the spurs of multi-point circuits, either at the branching point or at the customer's premises or both, depending upon operational considerations.

On long lines, addressable ALE could be provided along the route at strategic points. By polling each ALE in turn along the route, each section of line can be proved either working or faulty. A coded form of address signal which is transparent to the workings of the line and customer's equipment is essential if system security is to be achieved without encroaching on the bandwidth available to the customer. Each ALE must then be capable of being addressed to any one of the possible addresses. Once an ALE is set to an address, it must then be transparent to all other address signals.

Mini-Remote Access Test Equipment System

At exchanges where the number of private circuits routed through it is insufficient to warrant the provision of full RATES, a cost-effective approach may be to provide a form of addressable ALE, known as *mini-RATES*.

One possible solution is to provide a switching matrix which is accessed by an addressable ALE module fitted in a control circuit. The addressable ALE module controls the switching matrix through which the private circuits are routed. To test a particular private circuit, the control circuit is accessed and the address of the circuit to be tested is sent to the ALE address module. The addressable

ALE module then operates the switch, providing either a loop in the case of a 4-wire circuit or a tone back in the case of a 2-wire circuit.

This equipment could also be provided at large customer installations as a cost reduced form of ALE.

CONCLUSIONS

The use of ALE can play an important role in BT's objective to improve the maintenance of private circuits; it complements RATES and provides the capability to test to the customer's interface. Additional benefits may also be obtained during the installation of private circuits by providing the ability to check the local ends without engineering personnel being dispatched.

As the introduction of RATES in the network gathers momentum, the advantages of centralised testing are likely to increase the demand for the facilities provided by ALE in an effort to reduce circuit outage time and alleviate the problems of end-to-end testing prior to hand-over to the customer on installation.

ACKNOWLEDGEMENT

Acknowledgement is given to STC, Electronics Division, Treforest, Mid Glamorgan, for permission to publish photographs of the Test Units 21B and 22B Mk. 1.

Biographies

John Marshall is a Head of Group in Trunk Network Systems Engineering Division, BT Inland Communications. He joined BT in 1964 on the scientific grade at BT's Research Station at Dollis Hill and worked for some time on the development of high-reliability transistors for use in deep-sea repeaters. He was awarded a scholarship in 1966 for a full-time B.Sc. Honours degree in Electrical and Electronic Engineering and returned, in 1970, to the Local Line System Development Department where he was involved in early work with wideband television distribution systems. In 1972, he was awarded a scholarship for a one year M.Sc. course in Telecommunications Systems at Essex University and returned to BT's Transmission Systems Development Department, in 1973, where he worked on audio and miscellaneous repeater station equipment development. In 1981, he was promoted to his present position as Head of Group Network Management Systems where he is responsible for a number of major system development projects including ALE.

Gordon Hornsby joined the GPO in 1944 as a Boy Messenger and, in 1947, transferred to the engineering department under the Y2YC training scheme working in a manual exchange area. He completed two years National Service in the Royal Signals Regiment and then returned to the area and was employed on test desk, exchange maintenance and subscribers' apparatus duties. In 1954, he moved to Faraday, Long Distance Area, occupied on trunk and private wire testing and later as a Technical Officer on TAT, CANTAT and TASI maintenance. He became an Assistant Executive Engineer in 1961 engaged on oceanic planning and commissioning. The period 1964 to 1972 was spent with the Zambian P&T working on various aspects of line, transmission, telegraph, and radio equipment maintenance and planning duties. On returning from Africa, he was promoted to Executive Engineer and worked on the forerunner of the KiloStream service network. Since 1976, he has been employed on design and development of audio transmission, power and station alarm equipment and the ALE project.

Roger Price joined the Post Office (PO) in 1967 as a Trainee Technician Apprentice in the Cardiff Telephone Area. After completing his apprenticeship, he spent four years at college during which period he completed an HND and then CEI Pt. 2 in electrical engineering. As part of the industrial training of the HND, he was involved in a number of projects at what was then the PO Radio Research Station at Castleton. Later he returned to the Cardiff Telephone Area on exchange maintenance, during which time he completed the Diploma in Management Studies. In 1980 he was promoted and joined what is now the Network Management Systems Group, BT Inland Communications, on transmission development and worked on the development of ALE. He is at present a level 2 on project support for FAST in Local Line Services.

Martlesham Medal for Pioneer in Opto-Electronic Technology

BRITISH TELECOM PRESS NOTICE

Dr. Marc Faktor, a physical scientist whose pioneering work has helped to put Britain ahead in opto-electronic technology, has been awarded the Martlesham Medal. The Martlesham Medal gives recognition to members of British Telecom (BT), past or present, who have made an outstanding personal contribution to science or technology that has a particular relevance to telecommunications.

Dr. Marc Faktor, who spent more than two decades researching the optical and electrical properties of materials, was presented with the medal at a ceremony in the London Telecom Tower on 22 January 1987. Sir George Jefferson, Chairman of BT, described Dr. Faktor's achievements as 'quite outstanding in their versatility and significance.'

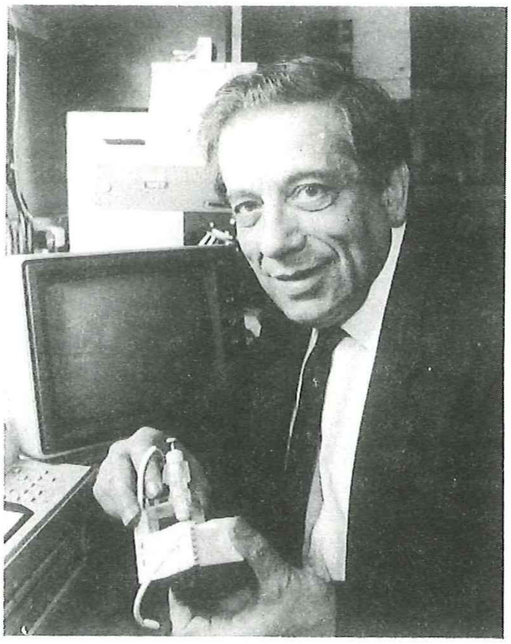
Research which Dr Faktor carried out in the 1960s and 1970s at BT's Research Laboratories has enabled the company to develop a new branch of micro-electronics which has significant value to telecommunications operators throughout the world.

Commenting on the award Sir George said: 'He has demonstrated an immense grasp of materials science, both in principle and detail, and a high degree of originality.

'Dr. Faktor is a fine example of a physical scientist who has always sought to produce results of technical and industrial value based on profound scientific theory and understanding.

'He was a key member of the Martlesham team which is still helping to expand optical-fibre communications. He has now returned to academic life and, combining this with his consulting work, he maintains that imaginative sparkle which keeps the UK among the foremost scientific and engineering nations in the world.

'Meanwhile, at Martlesham and elsewhere, BT sustains the forward-looking research of which Dr. Faktor is such a remarkable exponent. Make no mistake, research is a vital part of any nation's technological ambitions and BT is totally committed to playing its full part in this country's drive to stay in the forefront of world achievements.'



Dr. Faktor with the BT profile plotter which he helped to develop

Dr. Faktor was born in Poland and came to this country as a schoolboy of 16 in 1946, after grim wartime experiences. He left school at 17 and became a laboratory assistant. In 1951, he began work at a London tutorial college, first as a laboratory steward, later as a lecturer. Meanwhile, he attended evening classes at Birkbeck College, University of London, to achieve his first degree, in Chemistry, in 1955. He obtained a Ph.D. in inorganic chemistry in 1958, when he joined the research laboratories of BT (then the Post Office). He left BT in 1982 and is now a visiting professor at Queen Mary College, London University.

Much of his work with BT concerned growing crystals from vapour, that is, building up layers of semiconductor material no more than a millionth of an inch thick, on which the fabrication of today's optical devices is based. The techniques which he pioneered, such as metallo organic vapour phase epitaxy (MOVPE) are now sufficiently well defined as to be capable of commerical exploitation. The joint venture company set up in 1986 between BT and du Pont is to develop, manufacture and market opto-electronic components and devices which stem directly from Dr. Faktor's work.

The world-wide market for these devices is worth more than £350 million now and is expected to grow by 30 per cent a year to more than £4 billion by the mid-1990s.

Dr Faktor's work ranged widely over the field of opto-electronics and other semiconductors. During the early-1970s he headed a team which used organic materials to build reliable 'directly modulateable' semiconductor lasers. He also devised the electrochemical technique at the heart of the BT profile plotter, which produces an accurate profile of the electric-current carriers in semiconductors. This is now manufactured under licence and the third-generation is sold worldwide.

999 Emergency Service

UDC 621.395.348

The 999 emergency service in the UK was started 50 years ago in July 1937. It was first introduced in the London area and was extended over the next ten years or so to all automatic exchanges in the country. This article gives a brief history of the service.

INTRODUCTION

Throughout the UK, a standard telephone number, 999, gives rapid access to the emergency services. Special operator positions at British Telecom's automanual centres direct the calls to the nearest appropriate emergency service—fire, police or ambulance, and in coastal areas, the coastguard. Prior to the introduction of this service some fifty years ago, various alarm systems were in use.

FIRE ALARM SYSTEM

At the turn of the century in the London area, the main method of summoning assistance from the Fire Brigade was by means of call points mounted on street posts. This was known as the *Brown fire alarm system* after its designer, Mr. A. C. Brown. Each call point was connected to the appropriate fire station by a direct pair of wires and was activated by pulling a handle. This action completed the line circuit and caused a flap indicator to fall and the alarm bell to ring in the fire station. A buzzer fitted in the street post could be monitored by the watchroom attendant to verify that it was a genuine call and not a circuit fault. By 1913, however, the system was considered unreliable and the Fire Brigade turned out for every call.

In 1906 there were 675 posts in the London area. In 1928 this number had risen to 1300 and in 1936 to 1732. The number of calls received in 1936 was 9297. Of these, 5875 were genuine, 1304 were malicious false calls and 2118 were the result of electrical defects or other faults.

In an attempt to reduce the number of abortive turnouts, a new call point system was devised. This was known as the *Gamewell* system and was adopted in 1936. Up to 20 call points were grouped together and connected to the fire station by a single loop of wire. The call points were modified to include a coded signalling device to identify the particular street point in the group, and a 'succession' facility to prevent a second call point on the same loop from transmitting its code while the first one was still transmitting. The call points also included a telephone facility to enable the firemen to contact the fire station.

The value of verbal contact with the Fire Brigade had been demonstrated by chance some years earlier. In December 1909, a fire broke out some premises in Clapham Junction just as a linesman, Mr A. R. Bradman, was passing by. He ran to the nearest call point to raise the alarm, but had the presence of mind to couple his hand telephone to the circuit and was able to pass valuable information to the Fire Brigade so that additional appliances could be summoned immediately to deal with the blaze.

EARLY POLICE TELEPHONE SYSTEMS

In the 1930s, the need became apparent for a telephone system that would enable intercommunication between the policeman on the beat and the local police station, as well as to give the general public access to the emergency services. This requirement differed significantly from the fire call points in that voice communication would be the primary information medium and that selective signalling would be required to alert the policeman on the appropriate beat.

These call points were housed on street pillars similar to the fire alarm system or incorporated in police kiosks. The police had access to a handset telephone housed in a locked compartment. The public emergency service was provided by means of a loudspeaking telephone arrangement accessed by holding open a small self-closing, but non-locking, door.

999 SERVICE

By 1936, the general public were becoming accustomed to using the telephone network, which had grown to 2·5 million telephones, almost one million of which were in London. The number of street call offices had risen to nearly 20 000. About 40% of the telephones were connected to automatic exchanges.

One night in November 1935, a serious fire occurred at a doctor's house in Wimpole Street, Central London, in which five women died. Much publicity was given to a complaint from a neighbour that when he dialled the operator to summon the Fire Brigade, the fire engines arrived before the operator answered.

A subsequent inquiry revealed that, although there was only a small number of

operators on duty that night, they had already been informed of the fire and had alerted the Fire Brigade, but they were then kept busy dealing with other calls about the fire. The problem was that the operators had no way of knowing how urgent a call was until it was answered.

The solution was to have a special number that would enable the caller to jump the queue for the operator. Ideally, this number should be easily remembered and should be standard throughout the UK.

The 999 emergency service was introduced in the London area in July 1937. By the end of the first month, some 13 000 genuine calls had been received. In 1938, the system was extended to Glasgow, but subsequent progress was halted by the war and it was not until 1948 that all the larger towns with automatic exchanges had the service. On manual (central battery) exchanges, emergency calls from public kiosks were obtained by pressing the special EMERGENCY CALL button.

CHOICE OF NUMBER

The choice of number for the emergency service was really dictated by the equipment in service in the telephone network. The operator code at that time was '0', so that could not be used. Three digits were required for the number to work in the director areas, and three identical digits were considered to be easier to remember. Level 1 numbers were subject to false line seizure resulting from spurious contacts on the open-wire distribution system that was widespread throughout the country at that time, and levels 2–8 were already in use or not considered desirable.

Ultimately, it was the pre-payment (button A+B) coin box in use at that time that finally swayed the argument. These coin boxes required coins to be inserted before a local call could be made, but a special cam in the dial enabled level 0 calls to the operator to be made without any coins being inserted. A slight modification to this arrangement would enable a 999 call to be made without charge.

OPERATOR POSITIONS

The emergency calls arrive at special operator positions at automanual centres. At these positions, the incoming call usually triggers a buzzer and a flashing light. The operator takes details of the emergency and forwards the call to the appropriate emergency service control room.

INTRODUCTION OF CELLULAR RADIO

The introduction of cellular radio gave rise to further difficulties in calling the emergency services. Because of the mobile nature of the cellphone, it is necessary to identify the individual cell transmitter being used so that the nearest emergency service can be contacted. A further complication is that the service areas of the different emergency services do not necessarily coincide with each other or with the cell boundaries.

Initially, a limited emergency service was available in the London area using codes 995, 996 and 997 for fire, police and ambulance respectively. However, the two cellular networks in operation in the UK were designed to provide suitable information for the full 999 service, and this became operational throughout England and Wales during 1986.

CONCLUSION

The 999 emergency service in the UK is now 50 years old. Since its introduction, it has resulted in many lives being saved. At present, some 15 million emergency calls are handled each year at 220 centres throughout the country.

Difficulties of Specifying Users' Requirements for Computer Systems and Methods of Mitigating Them

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UDC 681.31

This article was first written as the basis of a local seminar on 'The Importance of Specification', presented to computer system developers and users. It discusses the difficulties of producing and verifying a system requirements specification (SRS), shows how these can be overcome or mitigated, and attempts to give users an understanding of their role in SRS production and the importance of their involvement in the project as a whole.*

The article does not address the subject of modern specification tools, such as specification languages. The purpose, rather, is to consider the fundamental problems in terms understood by users. Greater awareness and involvement of users would lead to better SRSs; and, if 10% of the specifications prepared within British Telecom (BT) were improved by 10%, BT could save millions of pounds in capital and maintenance costs.

INTRODUCTION

The formal procedure of staged development has for some time been accepted as the standard approach to the development of computer systems. In this, the complete process, from specification to acceptance, is divided into a number of discrete stages, each of which must be completed before the next is commenced. Indeed, each stage defines the requirements for the next.

For this approach to have the maximum beneficial effect on a project, completion of a stage means not only that the work explicitly demanded by that stage has been carried out (for example, designing the system or writing the software), but also that the implicit tasks of documenting and verifying the work have been performed.

The stages are essentially as shown in Figure 1. It will be seen that each has an earlier stage as a basis for verification, except the first. Yet the user's document of requirements, referred to as the *system requirements specification* (SRS), is the foundation of the entire project: if any stage requires verification, it is the specification stage. An error in the SRS may be taken by the contractor as a basis for design, and then becomes a part of the resulting computer system. In the worst case, an error in the SRS could result in inappropriate hardware being purchased and incorrect and/or unnecessary software being developed. This is costly to rectify. Indeed, it is said that the cost of rectifying specification errors, as the project advances, increases according to the 'factor of ten' rule; that is, such errors cost ten times more to correct at the design stage than at the specification stage, 100 times more at the coding stage, and 1000 times more during the operation and maintenance stage (see Figure 2). It is thus important for the SRS to be both complete and correct. Yet, for a number of reasons, it is the most difficult stage in which to achieve either completeness or correctness. And it is the stage to which formal verification methods are least applied.

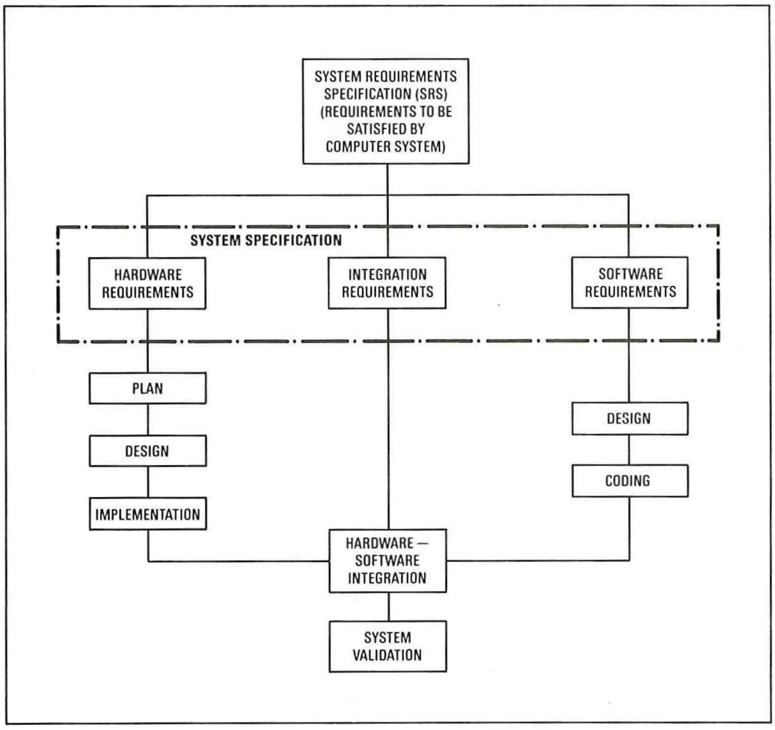


Figure 1
The stages of computer system development (adapted from reference 2)

In many, if not most, organisations, SRSs are poor, not only because of real difficulties, but also because they are treated casually. The SRS is often thought of as something to be finalised as quickly as possible so that the 'real work' can begin. Guidelines exist to improve the standards of both the form and content of SRSs [1] but, even when these are followed, inadequate knowledge, poor style and culpable attitudes result in poor SRSs.

† Planning Directorate, British Telecom International

* Parts of this article are based on *The Computer Primer* by Felix Redmill, published by Addison-Wesley

‡ CCITT—International Telegraph and Telephone Consultative Committee

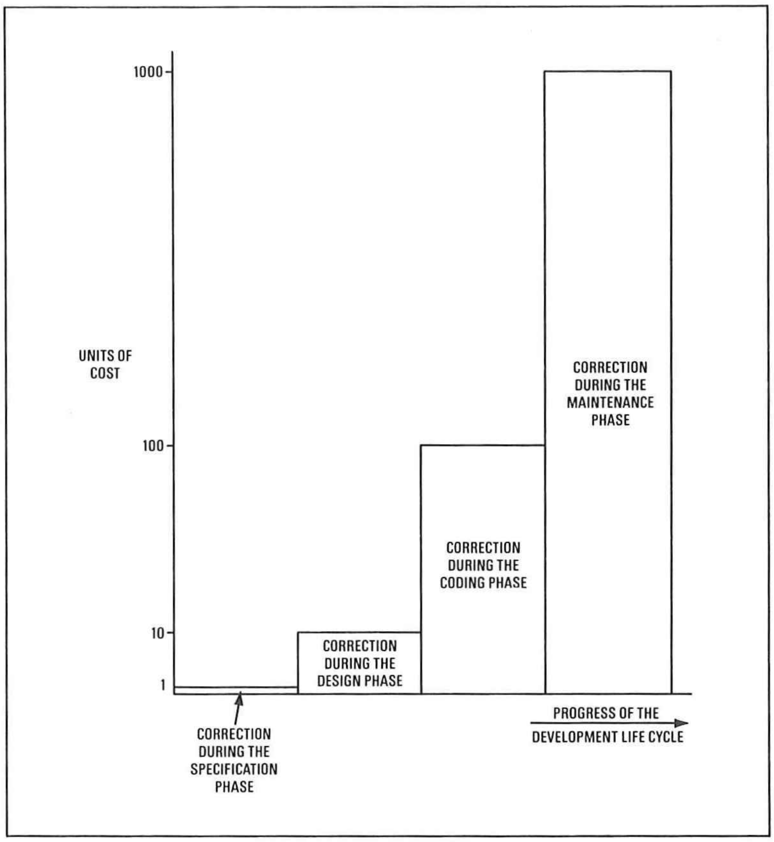


Figure 2
The 'factor of ten' rule for the cost of correction of specification errors

Most computer projects go wrong at some point, and many do so because of inadequacies in the SRS. An inadequate, badly written, or incorrect SRS leads to projects in some cases being aborted and, in others, being corrected; but in all cases time and money are wasted.

Decision tables can be used to aid the specification and design of applications which can be reduced to a finite number of simple logical decisions, and software aids have been written for this purpose [2]. The state transition diagram (STD) has also been used for the specification of telecommunications systems [3], as has the specification and description language (SDL), developed by the CCITT‡ [4]. Both of these are excellent for specifying the flow of control in steady-state systems. However, with the exception of such somewhat special cases, SRSs remain, in general, a problem area of the life cycle of the system. More general specification languages are being developed [5], but these are not in widespread use and they usually depend on, or recommend the use of, software tools with which the average user is unlikely to be familiar.

This article considers the problems that a user faces in producing an SRS, and discusses these in layman's terms. It draws together the main causes of inferior SRSs. It proposes a number of ways of finding and correcting the imperfections, as well as showing where opportunities arise for verification. Further, it recognises that the perfect SRS is not achievable, and suggests methods of increasing the probability of achieving a satisfactory finished product in spite of residual imperfections and the need for changes in the SRS. Finally, it focuses on the individual and collective responsibilities of the user and contractor in achieving these goals. First, however, certain key concepts need to be briefly defined.

KEY WORDS AND PHRASES

User This is the person or persons who are responsible for defining and specifying the requirements of the system, and who will use it or benefit from its use.

Contractor This is the person or persons who will specify, design and develop the system itself and who will hand it over to the user as a finished product. The contractor is almost invariably distinct from the user and this is assumed in this article. However, the contractor may be an employee of the user or the user's company.

System Requirements Specification (SRS) This is a document which states the requirements of the system to be developed, from the user's point of view. It states functional and environmental requirements, and not how they are implemented. The SRS is the user's responsibility, though it may be produced by a consultant on behalf of the user. It is on the SRS that the contractor bases the system specification.

System Specification This is a document, produced by the contractor, which proposes a computer system to meet the requirements stated in the SRS. The system specification, sometimes referred to as the *functional specification*, precedes a full design. It is intended to demonstrate functionality, and to identify the hardware and the main software modules so that costs, timescales and system dimensions for the development project can be estimated.

Verification This is the comparison at each stage of the development life cycle to determine that there is a faithful translation of one stage into the next [6]. The tests carried out to achieve verification depend on the system being developed and the stage of development [7].

Validation This is the process of determining the level of conformity between an operational system and the system requirements, as stated in the SRS, under operational conditions [6].

PROBLEMS IN PRODUCING AN SRS

The problems of achieving a superior SRS are considered in three categories:

(*a*) knowing or deciding what to specify;

(*b*) expressing the requirements as a complete, correct and unambiguous specification; and

(*c*) verifying the specification.

Knowing What to Specify

A computer system may be required to perform tasks previously undertaken

(*a*) not at all;

(*b*) manually, semi-automatically, or electromechanically; or

(*c*) by another computer.

In the first case, there is no precedent for the requirements of the new system. The SRS must evolve from nothing, and new facilities are added to the current specification as ideas arise. Changes are frequent.

In the second case, a precedent exists, but improved facilities are demanded. New ways of working, so as to derive the greatest benefit from computerisation, are necessary and, if they are not recognised at first, are introduced later after experience of the computer system has been gained. Recognition of optimum ways of working is often an evolutionary, rather than a spontaneous, process, and this necessitates changes even after the system is in service.

In the third case, there is a precedent, and perhaps even an earlier SRS, but almost invariably substantial changes are required. New and improved facilities, greater reliability, new forms of output, and interaction with peripheral equipment of a later technology, are typical examples. Verification of the new SRS against the old one can therefore at best be partial; and it is often misleading.

In all cases, the requirements for the new system evolve. There is always the possibility of new ideas or the recognition of better methods or facilities. Indeed, when the system is installed and the user has become more familiar with it, there is usually a spate of requests for changes, and this leads to expensive and often difficult perfective maintenance [8]. Two important issues are, therefore, to optimise the SRS in the first place and to recognise that it will inevitably be subject to change later.

In attempting to write the SRS, the user encounters the problem of not knowing what to specify. There are times when the user believes that the list of requirements is complete, but frustration sets in when this changes. There are also times when, instead of defining what the computer system is required to *do*, the user specifies what it should *be*. Sometimes the user recognises that the SRS is incomplete but does not know how to complete it, either because of lack of knowledge or because of an inability to capture the information (for example, data volumes).

To stand the best chance of achieving completeness and correctness, the author should use accredited guidelines [1]. These dictate the form and content of an SRS by providing a checklist of the topics to be covered, usually in the form of paragraph headings, and notes that explain the purpose and, perhaps, the level of detail of each paragraph. A guideline not only ensures that all topics are considered, but also groups and indexes information to make it easy to locate, amend or update; and it forms a standard for quality assurance of the document.

An SRS should also be the result of a thorough systems analysis. This implies the use of a trained systems analyst who understands both the users' objectives and computer systems. By studying the working environment, interviewing users, and investigating the system being replaced, the analyst determines the users' requirements, and then documents these according to the guidelines in use. In documenting the requirements, the analyst considers not only the uses to which the computer system will be put, but also the information which a designer requires to select an appropriate system; for example, the quantities of data to be handled by the system and the length of time it needs to be stored. As the intermediary between the user and the contractor, the analyst needs to communicate easily with both. However, users and systems analysts often 'speak different languages' [9]. If the user could bridge this gap, an analyst would not be required; so one needs to be chosen carefully.

The problem of users appreciating the possibilities of a computer system only after they become familiar with it can be mitigated by prototyping (this will be discussed later). But it is also necessary to recognise that the user and/or systems analyst is unlikely to produce a perfect and unchanging SRS. A formal agreement, covering the procedures for changes to the SRS, is therefore required between the user and the contractor, and should be a well-defined and integral aspect of project management. Such an agreement allows changes to be made: a system which meets a user's specification but not the actual requirements is useless and is likely to generate dissension. It also allows changes to be assessed so that the user has the opportunity to discard those which are too expensive or which adversely affect the progress of the project as a whole. Moreover, it ensures that changes are recorded and not claimed to be analysts' or contractors' errors.

Further, to allow for later changes, an onus should be accepted by system designers. Inherent in good design is flexibility so that later modifications and expansions can be implemented easily and without maintainability being jeopardised. In software, this is achieved via, among other techniques, modular design; in hardware, it is necessary to choose an upgradable processor or, if enhancement is a certainty, to purchase surplus power from the outset.

Producing the Specification

The first problem, and a surprisingly frequent one, arises when the user produces only a brief sketch of what is required, or no SRS at

all. This places the onus of definition on the contractor and leaves wide scope for error. The penalty to the user is that, if the contractor chooses to develop a system without seeking clarification, there is nothing in the SRS against which to validate the system or to show why the system is unsatisfactory. The user will be liable for its costs.

Of course, in most instances of an inadequate SRS, the contractor will try to improve it, sometimes by carrying out a full systems analysis, which often leads to a better SRS than the user would have produced. The disadvantage, however, is that the user, when asked to verify this, is in a position only to consider the judgement already made by a third party, rather than the conclusions drawn from the user's own logic.

A second problem is that, even when systems analyses are carried out, the analysts often derive too little of their information from the operational environment. The analysts quite correctly interview managers and investigate the ultimate purpose of computer output, but they seldom concentrate on operational difficulties. The result is that, during or after its development, the system has to undergo design changes, often fundamental ones, for it to interface with its environment or its operators.

A third problem arises when users do not recognise the SRS as specifying the functional or information requirements of the system from their own point of view, or as a document which they can understand. Too often they try to write it in computer terms. The results are that they become confused about what to write; they unintentionally leave out many requirements because they cannot map them onto a computer system; they intentionally omit others because, from limited knowledge, they cannot see a way of implementing them, or believe them to be too costly; and ultimately they present the contractor not with an SRS, but with a partial design, and often one which is inappropriate to the user's real requirements.

A fourth problem is that users often do not recognise that the SRS needs to contain information on the environment in which the future system must function [10]; for example, it should contain details of interfaces with other equipment, operational and accommodation constraints, etc. The degree to which the finished product is optimal, not only functionally but also in matching its environment, then depends on how thoroughly the contractor reinvestigates the requirements and rewrites the SRS. If environmental information is to be specified adequately and in its proper context, the need for a competent analyst must again be emphasised. To quote Scharer, 'Users who try to define a system with the analysts' goals in mind can find themselves in a predicament, particularly when one of the following is true:

The system is just not definable by traditional means.

The system can be defined but the user doesn't really know what he wants.

The user knows what he wants but can't articulate it' [11].

A fifth problem is that managers often fail to allocate the responsibility of writing a specification to a good author. The result is a badly written document. Uncertainty in the interpretation of the SRS leads to a great deal of time being spent in clarification. However, if the contractor does not recognise the need to seek interpretation, its errors will be designed into the system and the matter becomes one of recrimination—perhaps, not until acceptance testing, or even during service. It is therefore important for users to ensure that the writing of SRSs is entrusted to skilled writers, and preferably to competent analysts. An analyst is not only more likely to uncover the correct information, but also to use structured analysis methods in its documentation [12, 13]. It should also be noted that, although many guidelines do not specifically demand the use of diagrams, these greatly aid explanation and go a long way to overcoming ambiguity. Data flow diagrams, flow charts, and ordinary block diagrams should be used whenever possible.

A further problem in the production of specifications is that managers do not take the task seriously and thus do not allocate adequate time to it. They often see it not as an important job but as a chore to be endured only so as to maintain appearances. They urge their staff to dispatch the job in the shortest possible time and do not encourage or insist on either quality assurance or verification of the document.

Problems in Verification

Verification is not often formally considered with respect to an SRS. It is difficult to carry out and, not only is verification not performed, but its absence is seldom seen as a deficiency. Yet, although it is recognised that every other development stage should be rigorously verified, the SRS is probably the most important stage in the development life cycle: errors at that stage can seed themselves into both the hardware and software subsystems, becoming design features and being difficult, costly, and sometimes impossible, to correct.

There are many reasons why the SRS does not receive adequate verification, and many of these stem from the user's difficulties in knowing what to specify. In the first place, there is the problem of not having an earlier document or stage of development against which to verify it. Very often the first real verification test is when the contractor has interpreted the SRS into a system specification and offers this to the user for comment

and discussion [14]. Unfortunately, the user usually misses this opportunity to verify the SRS. Too often the review of the contractor's system specification is limited to confirming that budget and time-scales are acceptable, and does not even include a thorough check of the contractor's interpretation of the requirements of the system. The user, in the form of the analyst and end users, should be prepared to devote time to reviewing the contractor's system specification when it is prepared. They should check the mapping of the SRS onto it and thus look for inadequacies, or even excesses. This verifies not only the system specification but also the SRS.

Secondly, with requirements constantly changing, there is often a feeling that there is no point in going to too much trouble over verification, as the specification is likely to change anyway.

Thirdly, very often one author attempts to draw together the requirements of a number of users, and problems arise at the interfaces between them. The users often allocate very little of their time to specifying their requirements and even less to verifying them or informing the author of changes. The author is often short of time and, not having direct authority over the users, takes the view that, if they are not prepared to be co-operative in securing their own interests, they deserve their fate. A systems analyst should have adequate skills for surmounting such obstacles, but is still likely to encounter the problems, and an analyst with a knowledge of the system's environment is an asset. In general, an analyst introduces accredited techniques in dealing with users, documenting data flows, analysing output requirements, etc. To assist the analyst, and so enhance the likelihood of a good SRS, a user's staff should formally be instructed not only to co-operate, but also to devote the necessary time to discussing and defining their requirements. They should be made to verify their requirements after the SRS has been drafted. This is best achieved in the form of quality assurance which should involve both walks-through and a more formal review procedure. The principles of document 'inspection' were proposed by Fagan [15], and these now form the basis of a number of quality assurance 'methodologies'. Getting staff to allocate time to the production and verification of an SRS is, however, a management issue. Too often the staff are keen but their managers do not recognise the importance of the work and allocate insufficient time and resources to it, even discouraging it in some cases.

Another aid to verification is for the SRS to be 'frozen' when it is given to the contractor. However, it should be recognised that, if the user is to receive a satisfactory system, changes will be necessary, but these should be dealt with by the formal change control process discussed earlier. Freezing the SRS creates a reference point both for later changes and for verification.

Further opportunities to verify the SRS occur when the user designs system acceptance tests, or endeavours to agree these with the contractor. Since these should be functional tests, they should be based on the SRS; their relevance and completeness can be judged only by comparing them with the SRS. A comparison of what is specified in the acceptance test descriptions with what is actually in the SRS provides a verification test of the SRS. A diagram pointing out the opportunities for verification of the SRS is shown as Figure 3.

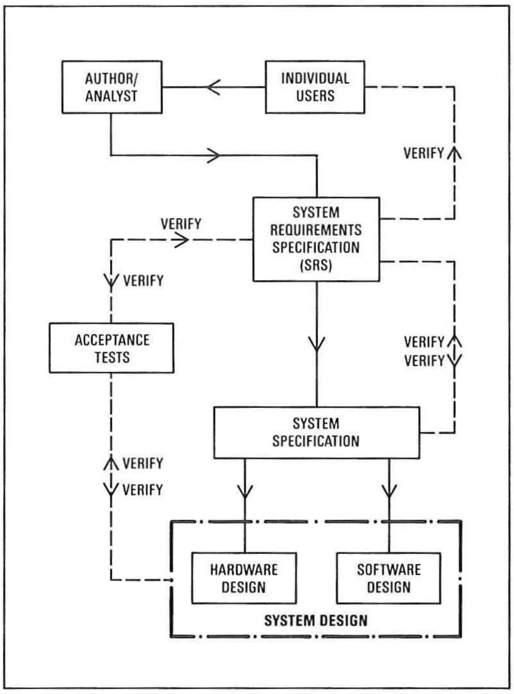


Figure 3
Opportunities for verifying the SRS in computer system development

PROTOTYPING AS AN AID

For some of the problems mentioned in the previous section, solutions or partial solutions were proposed and, for many, the mere statement of the difficulty revealed obvious ways in which it could be overcome or mitigated. However, the problem of the user not being sure of the final requirements cannot summarily be dismissed. The likelihood of the user changing or adding to the SRS during development, or, indeed, after the system is operational, is high. And this likelihood will not be eliminated by improving the quality of SRSs. The fact is that until the user has experience of a system, many of the facilities which it could offer are not envisaged. It has been shown [16] that, on average, 60–70% of the software effort invested in a system is during the maintenance phase, that is, after the system is in service, and most of this effort is in adaptive or perfective rather than corrective maintenance. The way to reduce this maintenance effort is to provide the user

with experience of the system during the development phase. This implies either incremental development (discussed below) or prototyping.

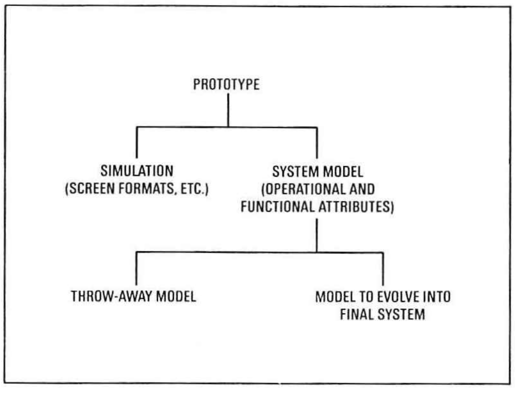
Prototyping is not a new concept and is only briefly discussed here in order to draw it together with other methods of overcoming the problems of producing an SRS. It should be noted that prototyping, except at a very early stage in the project, does not, in the first instance, improve the SRS; but it allows the gaps, or probable gaps, in the SRS to be filled in a methodical and efficient manner prior to acceptance testing. It improves the chance of achieving a satisfactory end product in spite of the likely inadequacies of the SRS, and it allows modifications, which would otherwise have occurred in the maintenance phase, to be identified and implemented in the development phase. It is also suggested that prototyping 'cuts the work to produce a system by 40%' [17].

The first kind of prototype (see Figure 4) is a simulation, usually quite simply contrived, of the system or certain aspects of it. This is useful for showing the user what computer outputs are expected to look like, so that an early feel for the system and an idea of how the contractor has interpreted the requirements can be obtained. Almost invariably, changes will be requested, sometimes fundamental to the project, at other times only to outputs—to split or combine them or to change their formats.

The second kind of prototype is the system model, intended to exhibit the attributes of the final system operationally, functionally, or both. On this, computer operators and terminal users can perform their functions as they would eventually do on the developed system. Appropriate modifications can thus be requested, implemented and reviewed. There are two sub-sets of this kind of prototype. One is a 'throw-away' model whose life ends when its purpose as a prototype is accomplished. The other evolves into the final system. The evolutionary model is more cost-effective when the final system is one-off. The cost of the throw-away model is more easily accommodated when the final system is to be replicated. Whichever is employed, the principle of providing the user with early experience of the proposed system, modifying the prototype in accordance with the user's requests, reviewing the modifications, and iterating towards an ideal system, is one which goes a long way to mitigating the problems inherent in SRS production.

Useful tools for the contractor in prototyping are fourth generation languages (4GLs). These increase programmer productivity and reduce prototyping time. An interviewee is quoted [18] as saying, '..but we've always written wrong programs, the specs were wrong and by the time we got the programs going the users wanted something different anyway. What's new about 4GLs is that we can now produce wrong programs fast, so fast that there's no penalty in being wrong. Because we can write them again. We can write them again each time the user gets a clearer picture of what he really wants'. This illustrates rather well the difficulty in knowing what is required and the benefits of prototyping in assisting the user. However, it also suggests that easy and rapid prototyping may have the effect of inducing a casual attitude towards SRSs. This would be unfortunate. While a prototype is invaluable for iterating towards certain requirements, an SRS should contain a great deal more information, which only a thorough analysis of data requirements, working and operational practices, and environmental conditions, followed by a well written document, can provide. It must be remembered that prototyping is only an aid to solving the specification problem and not a total solution. If it is taken out of context, it will, in many cases, do as much harm as good.

Figure 4
Prototyping



EVOLUTIONARY DEVELOPMENT AS AN AID

The traditional model of the development of a computer system is shown in Figure 1. In this, development proceeds from stage to stage until the total system is complete. Some of the disadvantages of this result in SRS errors not being recognised until development has been concluded. For example, the user is often excluded from the development and project management processes; a problem in the development of any function of the system can lead to delay in delivery of the whole system; changes resulting from users' experience of the system accumulate rapidly to create a large and expensive load on the maintenance team.

These and other disadvantages can be overcome, to a large extent, by 'incremental development' in which the most urgently needed functions are developed and delivered early. Then, further functions are integrated into the working system when they have been developed. Thus, while development proceeds, the users are able to have the use of the

system, the opportunity of testing the functions already provided, and experience of the system which leads to changes—but, now, in the development rather than the maintenance stage of the project. Thus, incremental development incorporates a form of prototyping with the evolution of the system. Krzanik [19] has this to say of incremental development (and delivery):

> 'The incremental strategy first installs an incomplete system with a general control framework and at least one significant, operable, end-user capability. From then on, an incremental project produces a stream of additional user capabilities. The strategy is similar to the "top-down development" approach in the sense that the general control level of the system is completed before lower levels are implemented. The strategy allows to program (*sic*) and install a system even if the users' requirements are ambiguous. This is accomplished by designing a generalized system framework which can be later incremented with the programs that perform detailed functions.'

This statement recognises the difficulties in SRS production and proposes incremental development as a means of mitigating them. Gilb [20] refers to the process as 'evolutionary delivery' and recommends it for the same purpose. Incremental development is not a panacea and does not obviate the need for an SRS, project planning, project management or quality control, but it does offer the user early involvement with the system, and it allows some of the problems of specifying requirements to be overcome.

RESPONSIBILITIES OF USER AND CONTRACTOR

The previous discussions of this paper are summarised in Figure 5. Finally, in order to stress that the user's responsibility for the final product is as great as the contractor's, an outline of the responsibilities of these two parties [21] is presented.

User To provide as complete, correct and unambiguous an SRS as possible. This implies assigning a systems analyst to study the requirements and write the document. Standards of form and content should be adhered to in its production; individual users should devote time to defining their requirements and verifying them by reviewing the completed SRS; the analyst should consider operational and environmental as well as functional matters; and the SRS should be a statement of requirements and not an attempt at system design.

Contractor To study the SRS and seek clarification of any uncertainties or ambiguities. Further, the contractor should be encouraged to question the need for specified facilities if they appear to be illogical or unnecessary.

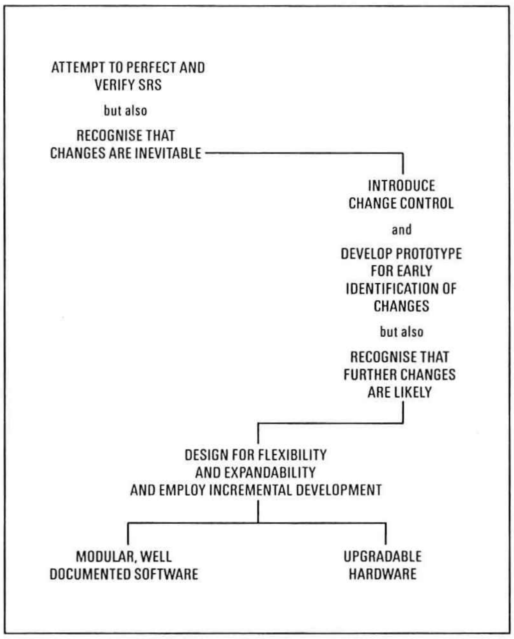


Figure 5
Minimising the problems of specification

Contractor To interpret the SRS into a system specification and to present this to the user for discussion and verification.

User To study the system specification carefully, compare it with the SRS for completeness and correctness and, in understanding it as the contractor's interpretation of the SRS, to use it as a means of verifying the SRS.

User and Contractor To adjust the SRS and system specification until the users' requirements are clear and well documented and their interpretation into the system specification is understood and agreed.

User and Contractor To agree a change control procedure so that new and changed requirements meet with a formal method of presentation, documentation, review and implementation. This ensures that they are handled optimally and that the contractor receives credit for extra work rather than disparagement for delays to the project.

Contractor To recognise that the user will only appreciate the possibilities of the system after becoming familiar with it and, if at all possible, to provide a prototype at an early stage of development.

User To use the prototype and become familiar with it.

User and Contractor To explore changes to the prototype so as to iterate towards an optimal system.

Contractor To recognise that later changes are inevitable and to cater for these by designing for flexibility and expandability. Ways of achieving this include functional decomposition and modularity of software and the use of upgradable hardware which provides upward compatibility for the software. Further, incremental development and delivery, rather than the 'big bang' approach,

allows many specification errors to be revealed early and gives the user early experience of the system.

User To design system acceptance tests, based on functionality as stated in the SRS, and agree them and the method of applying them with the contractor. It may be necessary to employ consultants to assist with this, and it is helpful to do it as early as possible.

Contractor To study the proposed acceptance tests and compare them with the SRS. This is another opportunity to verify the SRS, because the tests may be designed to prove functions which the user thinks have been specified, but which the contractor has not understood to be in the SRS.

Contractor To provide effective project management and quality control; also to employ good verification at every stage of the development so as to ensure that the SRS and later legitimate changes are translated faithfully into an effective final product. Also to validate the operational system against the SRS and the later changes.

CONCLUSIONS

Most computer development projects experience problems, and many of these stem from inadequacies in, or changes to, SRSs.

The problems of SRS production have been discussed under three headings; knowing what to specify, producing the specification, and verifying it. Methods of improving the SRS have been proposed, and it has been shown that there are a number of opportunities for verifying the SRS, at the time of writing it and later.

While many development crises can be avoided by having superior SRSs, users will continue to make changes to their requirements, particularly after they have gained familiarity with the system. To identify these changes in the development phase rather than the maintenance phase, prototyping is recommended. This enhances the probability of a satisfactory production system in spite of the likelihood of change to the SRS. Further, as a precaution against the undesirable effects of later changes, flexibility and expandability should be design features. These imply functional modularity of software and the use of upgradable hardware.

There has also been a trend towards incremental development and delivery of computer systems and this, if used wisely, can overcome some of the problems of specifying requirements.

Finally, it has to be recognised that the user's role, as well as the contractor's, is crucial to the success of a development project.

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Biography

Felix Redmill is currently Network Information Systems Manager in British Telecom International's Implementation and Design Division. Prior to this, he was responsible for maintenance support for telephone exchange and computer systems. His career in BT has taken him into many areas of both telephony and computer systems, including teletraffic engineering, stored-program control and computer system development standards.

Recovery of Cables from the River Tyne

D. GREEN†

INTRODUCTION

In January 1986, digitalisation finally ended the need to maintain the Middlesbrough–Newcastle Nos. 1 and 2 carrier cables. But this technological advance brought in its wake another, more immediate problem. The Port of Tyne River Authority (PTA) informed British Telecom (BT) that it considered the subaqueous section of the cables laid in the bed of the River Tyne to be a navigational hazard and that, under the terms of the wayleave agreement, they had to be removed within three months. This article describes the unorthodox method that was used to recover these cables.

CHOICE OF METHOD

The cables were buried some 1 m in the bed of the River Tyne, and their recovery posed a difficult problem. Also, during the preliminary analysis, the drawing-office records revealed that a third obsolete cable, the Low Fell–Newcastle No. 1 cable, lay buried close by the other cables.

One possible solution was to use divers equipped with water jets to expose the cables, which would then be lifted out of the water by a floating crane. However, this operation would have proved extremely expensive.

In June 1986, it was suggested at a site meeting that the problem might be overcome by using a ripcord method of retrieval. A steel hawser would be passed across the river and attached to one of the cables; then a winch would be used to peel the cable back on itself like a rip cord. It was finally decided to adopt this unorthordox but ingenious method, and detailed planning began.

CHOICE OF SITE

The south bank of the river was chosen as the winch site. It was not ideal since the amount of working space available was restricted. Moreover, the site was positioned about 400 m from the nearest road along a rough track which was sandwiched between the river and the main Carlisle to Newcastle railway line. Because of the closeness of the railway line, British Rail (BR) considered that the operation could be a hazard to rail traffic, and insisted on having an engineer permanently on the site while the work was in progress. The BR engineer would be in contact with a nearby signal-box and would warn the site if trains approached so that winching could be stopped. In addition, a fence had to be erected between the railway line and BT's equipment on the site.

When told of BT's scheme to remove the subaqueous cables, the PTA stipulated certain conditions to ensure that its bye-laws were not infringed:

(*a*) BT was required to give at least two weeks notice of work beginning so that the PTA could issue a Notice to Mariners. The financial expense of this was to be borne by BT.

(*b*) BT was required to bear full responsibility for the operation, and this was to include responsibility for any deaths, personal injuries or damage to property which might occur either directly on indirectly from the work; BT would be required to indemnify the PTA accordingly and to make no claim against it.

(*c*) BT was also required to restore the banks on both sides of the river, where work had been undertaken, to the satisfaction of the PTA's Director of Engineering.

At the same time, the Harbour Master insisted that, during the actual process of winching, a launch with a river inspector on board, should be stationed nearby.

PROJECT COMMENCES

By July, a cost estimate had been prepared and submitted for authorisation. After consultation with BR, the PTA and the tide timetables, 16 September was chosen as the date to begin excavation work, and the following day the actual winching operation.

The insurance to cover the chartering of the motor launch from the PTA proved to be a problem since this type of operation fell outside BT's normal insurance cover. The cost of further premiums would have been high. Finally, authority was given for BT to carry its own insurance.

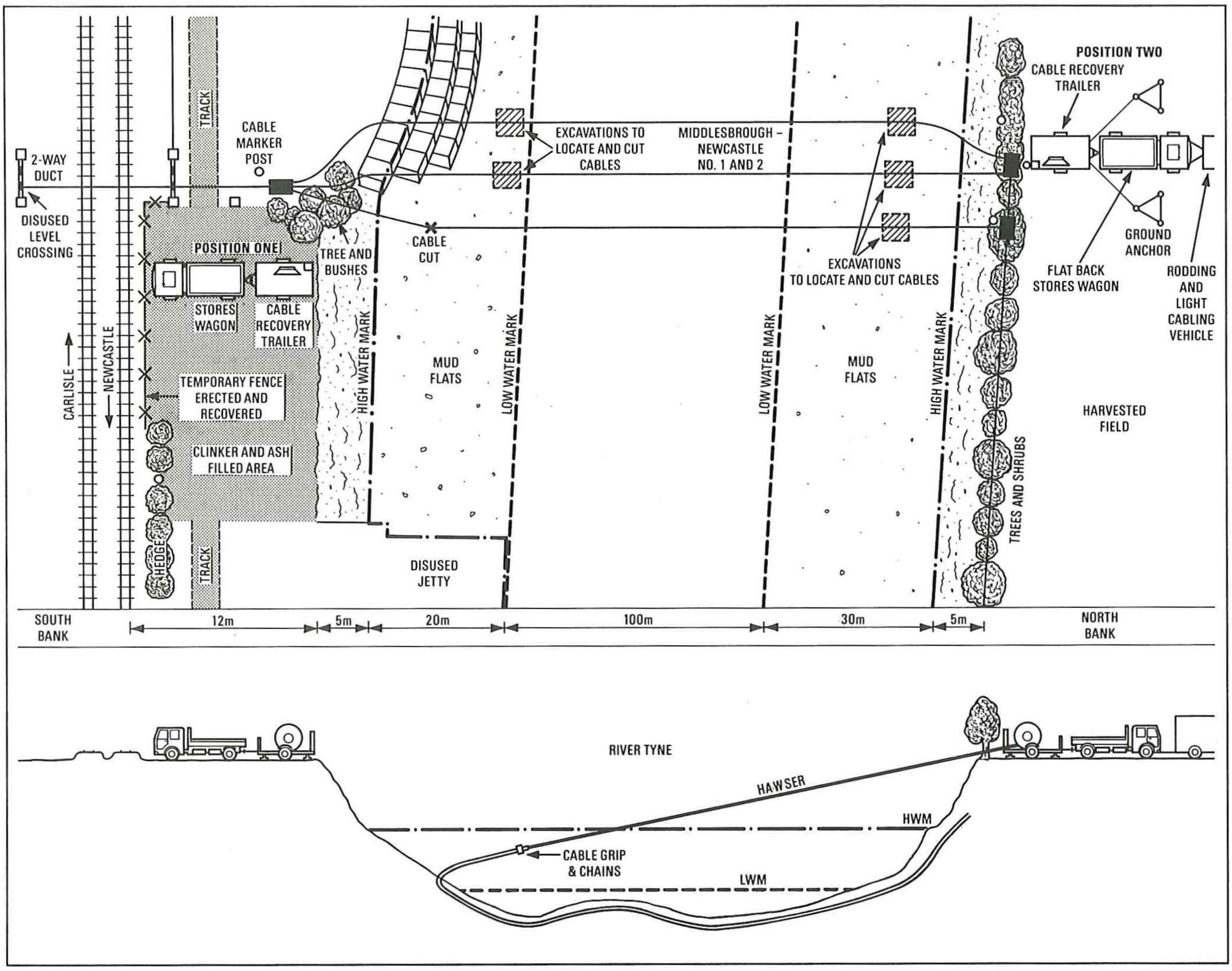
REMOVAL OF THE CABLES

At low tide on 16 September, the contractor located the cables with the help of BT staff and then excavated the draw pits. The cables were cut and prepared for recovery.

Early the following morning, the fence was erected and the site generally prepared. When the launch arrived at low tide, it took a line across the river; in turn, this was used to winch across a cabling rope, which was then used to winch across a steel hawser, loaned to BT by the PTA and having a breaking strain of 38 tons.

Winching began after the hawser had been

† North East District, British Telecom Inland Communications



Recovery operation

shackled to the cable grips on the end of the first cable, and permission to begin had been obtained from BR's engineer. Initially, everything went well. The winch took up the strain and the subaqueous cable began to peel back as anticipated at about 2–3 m per minute. However, after about 20–25 m of cable had been pulled back, the load suddenly increased and the winch virtually stopped. In fact, because the strain had become so great, the winch, together with the 4 ton stores wagon to which it was hitched, was being dragged down the bank towards the river. Attempts were made to anchor the winch and the vehicle, but still the cable remained stationary and the winch moved when the strain was applied. A rodding-and-light-cabling vehicle was hitched to the winch, which was also repositioned, in an attempt to anchor it more firmly. But this proved to be of no avail, and the train of BT vehicles again moved down the bank when work was restarted.

At this point, the work was curtailed; the hawser was passed back across the river, and the loop of cable settled into its original position to allow river traffic to proceed. It was decided to reverse the procedure and undertake the winching from the north bank of the river, since the ground there seemed firm enough to anchor the winch with two 3 ton ground anchors.

Work recommenced at low tide on 18 September; this time it proved successful. The first cable was winched out until approximately 25 m had been hauled up onto the bank; the cable was then cut at the water's edge with a stihlsaw before the hawser was reattached and another 25 m withdrawn. In this way, 125 m of cable were recovered from the river. The recovery of the other four cables, which had been laid in two pairs, took a further two days, and another two days were expended on cutting and stacking the cable onto pallets.

Biography

Dave Green started his career in 1966 as a TTA in Newcastle upon Tyne where he has spent all his working life. He has worked as a T2A and TO on external planning and, since 1982, on main and junction network cable planning. He was temporarily promoted to MPS Band C on these duties in 1984 and, since 1985, has been responsible for the commissioning of optical-fibre cables in the northern half of the North East District junction network.

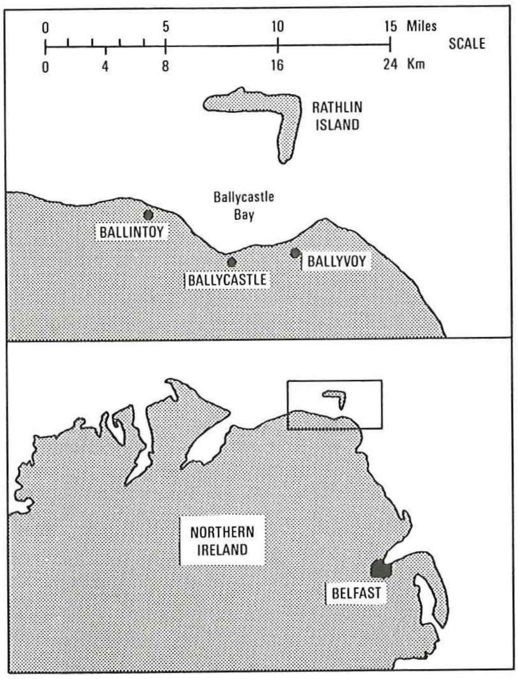
19 GHz Radio System for Rathlin Island

W. D. BOYD, B.SC., D.M.S., C.DIP.A.F., A.M.I.E.E., DIP.E.E.†

Rathlin Island, which lies 4 km off the northern coast of Northern Ireland, has a small population, of which 46 are telephone customers. The island's transport for people, livestock and fuel oil is by motorboat to and from Ballycastle on the mainland.

In 1976, a permanent telephone exchange building was constructed at Rathlin and a small Strowger switching unit (UAX13) installed. At the same time, a radio tower 22·5 m high was erected at the Ballycastle exchange site and a six-channel ultra-high-frequency (UHF) radio link provided to replace the three existing very-high-frequency (VHF) links. The batteries powering the exchange and radio equipment on Rathlin were recharged by two diesel generators operating for eight hours on alternate days. Maintenance of this equipment was carried out by staff travelling from Ballycastle; and in the winter months especially, this presented considerable difficulties.

The advent of 19 GHz digital radio systems made it possible to link each of the Rathlin customers directly to Ballycastle TXE2 exchange, and so reduce the maintenance problems and improve the service by discontinuing the use of the UAX on Rathlin and replacing the UHF radio link with modern equipment. As the hop length is 11 km, it was considered prudent to test the proposed radio link thoroughly before proceeding further. Accordingly, in 1984, tests using 19 GHz Farinon SR1536 subscriber radio equipment with 0·6 m dish aerials at each terminal were initiated. The aerial at Ballycastle was mounted on the tower at 27 m above sea level (ASL) and at Rathlin just above roof level on a steel pole at 55 m ASL. These tests showed that fading was causing an unacceptable level of errors; so it was decided to replace the aerials at both ends with larger ones having a diameter of 1 m. These produced the desired results, and continuous monitoring over a period of six months confirmed that the radio link was viable in the 8 Mbit/s mode.



Location of Rathlin Island

Equipment Digital Multiplex 6000A (2/8 Mbit/s MUXs) and Equipment PCM Muldex 6000 (2 Mbit/s MUXs) were installed at each terminal and overall tests of digital transmission were conducted successfully. However, final testing of the arrangement was delayed until suitable signalling units (SU PCM) for interfacing to the Ballycastle TXE2 exchange and to the Rathlin Island telephone lines became available in mid-1986. These were SU PCM No. L7/1 at Ballycastle and SU PCM No. K7/1 at Rathlin.

The Rathlin customers were given direct lines on Ballycastle TXE2 exchange on 28 August 1986; and there has since been a significant improvement in service.

† Northern Ireland District, British Telecom UK Communications Division

THE INSTITUTION OF BRITISH TELECOMMUNICATIONS ENGINEERS

(Founded as the Institution of Post Office Electrical Engineers in 1906)

General Secretary: Mr. J. H. Inchley, LNS2.1.1, Room 543, Williams National House, 11–13 Holborn Viaduct, London EC1A 2AT; Telephone: 01–356 9020.

(Membership and other enquiries ahould be directed to the appropriate Local-Centre Secretary as listed on p. 251 of the October 1986 issue.)

NEW SECRETARY OF THE INSTITUTION

The present Secretary to Council, Mr. John Bateman, will be replaced by Mr. Jonathan H. Inchley with effect from the Annual General Meeting on 14 May 1987.

Mr. Bateman took over from Mr. Roy Farr in November 1983. During his term of office, many of the time-honoured procedures associated with the former origins of the Institution have been considerably modified. In particular, grade representation on Council has been abandoned in favour of direct nomination of delegates by Local-Centre committees. This welding together of the Local Centres and Council should ensure that there is little chance of Council being out of step with the requirements of its members. Also during this period, extensive modifications have taken place in the relationship between the *Journal* editorial hierarchy and the main Institution organisation. Members should by now have benefitted from the automation of direct mailing arrangements. These same procedures should soon allow members to receive Local Centre programmes, membership cards etc. directly.

Mr. Bateman's successor, coincidentally, obtained his degree in electronic engineering from the same university (Sheffield), though one year later in 1971. Mr. Inchley has been Assistant Secretary of the Institution since May 1983.

John Bateman **Jonathan Inchley**

IBTE CENTRAL LIBRARY

The books listed below have been added to the IBTE Library. Copies of the 1982 edition of the Library Catalogue are available from the Librarian, IBTE, 2–12 Gresham Street, London EC2V 7AG. An abbreviated catalogue was bound in with the *Supplement* included with the October 1986 issue of the *Journal*. Library requisition forms are available from the Librarian, from Local-Centre and Associate Section Centre Secretaries and representatives. The forms should be sent to the Librarian. A self-addressed label must be enclosed.

Alternatively, the IBTE Library will be open on Wednesday mornings between 11.00 and 13.30. Members are advised to telephone the Librarian (01–928 8686 Extn. 2233) to confirm their visit. Members wishing to reserve books or check availability should contact the Library during opening times on 01–356 7919.

The Library is open to Full, Associate Section and retired Members of the IBTE.

5442 *In Search of the Big Bang*. John Gribbin.

This book tells the story of the Universe from the moment of creation to the present day. It shows how close physicists are to relating the two great theories of science: Einstein's General Theory of Relativity, which describes the Universe at large and the nature of space and time, and quantum physics, which describes the very small world within the atom and the interchange of mass and energy. The unified theory explains the origin of the Universe and its subsequent evolution. The book traces the historical path which has led to an understanding of the Big Bang, the fireball in which our Universe was born.

5443 *Computer Communications*, Second Edition. Robert Cole.

In this revised edition, the author explains the basic principles of data communications and applies them to physical applications. The components of character-based communications and terminal networks are covered along with the most up-to-date thinking on computer network technology and network architecture. The emerging international standard for Open Systems Interconnection is discussed along with its application to end-to-end service networks.

5445 *Introduction to Data Communications and LAN Technology*. Ed da Silva.

This book is written specifically for those without any technical knowledge of computer communications. It explains the principles of modems, interfaces and protocols, local area networks, OSI, and other topics in such a way that technical terms are made easy to understand. Considerable use is made of illustrations and case studies to make the book a practical introduction to the subject.

RETIRED MEMBERS

Members about to retire can secure life membership of the Institution at a once-and-for-all cost of £10·00 and so continue to enjoy the facilities provided, including a free copy of this *Journal*. Enquiries should be directed to the appropriate Local-Centre Secretary.

Book Reviews

Satellite Communications Systems.
G. Maral, and M. Bousquet.
John Wiley and Sons Ltd. xvii + 401 pp. 215 ills. £21·95.

The aim of this book, as paraphrased from its Preface, is to provide an overview of all aspects of satellite communication systems to students, engineers or scientists wishing (surely not 'willing', as stated in the Preface!) to enter the field. Secondly 'it can also be considered as a useful handbook to practising engineers'. The emphasis of the book is definitely to present all aspects of the subject, and it is probably here that it differs from the plethora of books which have recently been published in this field. It is certainly a handbook, and not a textbook. Pertinent, and useful, working equations are given but, in general, not derived for each topic covered. There are nine chapters covering:

An introductory history of international and national satellite systems.

Communication techniques (link budgets, propagation, signal processing, conventional versus regenerative transponders, radio regulatory considerations etc).

Satellite networks (access techniques, with a strong emphasis on time-division multiple access (TDMA), satellite switched (SS) TDMA and future proposed systems such as multibeam regenerative satellites).

Geometrical orbital and antenna considerations (tracking, coverage areas, eclipses etc.).

The space environment and its effects.

Satellite construction and satellite subsystems.

Launching and positioning of satellites.

Earth station technologies.

Reliability.

As a result of the wide range of topics covered, some are given scant attention. For example, digital modulation is covered in less than four pages (demodulation is covered in half a page) and forward error correction is dealt with on a single page. However, the intention is obviously to convey the principles of the topics covered and each chapter contains a comprehensive list of recent references (up to about 1980–3) which include the well-know standard texts on the specialised topics. The principles of all the major multiple access techniques are well covered. Next-generation techniques such as regenerative (on-board processing) transponders, SS TDMA and multibeam regenerative switching satellites are also clearly explained. Indeed, in the communications area the authors have placed some emphasis on looking ahead at future possibilities and the book is very much up-to-date in this area. In dealing with propagation effects, the difference between pure Faraday rotation of the plane of polarisation of a transmission and 'true' depolarisation resulting from rain and/or ice on the path is not explained (ice is not mentioned in the text). The 'major role' of precipitation scattering in coupling between different systems is a debatable subject, as is the effective temperature of the attenuation medium on the slant-path. However, the interested reader is generally pointed in the right direction for further in-depth study, as is true throughout the book.

The book does indeed provide the communications engineer with the opportunity to appreciate in a single volume, at an understandable level, all the aspects of satellite and space technology which make the job possible. These include basic orbit theory, attitude and thermal control of the satellite, electrical power supply, propulsion subsystems, antennas, telemetry, tracking and command, station-keeping, the hazards of the space environment and how they are overcome or minimised, launch vehicles, etc. Incidentally, the book (as does every other book in the reviewer's knowledge which mentions the subject) propagates the myth that geostationary satellites describe a figure-of-eight orbit. This is theoretically true in the ideal case, but ten years of observing geostationary satellites indicates that it does not happen in practice. The explanation of this is almost certainly that the figure-of-eight is opened up by the East–West (or West–East) drift of the satellite due to the non-uniform gravitational potential around the geostationary orbit.

In general, the aims and objectives of the authors of the book, which were mentioned above, have been very adequately achieved and I have no hesitation in recommending the book as required reading for anyone entering the field and needing an up-to-date (and forward-looking) overview of the whole area of satellite communications systems.

Finally, the book has been translated from French and a number of editorial errors have crept in, including at least one incorrect equation which I leave the reader to find as an exercise. Also, in a few cases the omission of brackets could lead the unwary reader astray.

J. THIRLWELL

Telecommunications Engineering.
H. G. Brierley.
Edward Arnold. viii + 278 pp. 96 ills. £11·50.

This book, which is intended for students in the final year of their electrical engineering degree courses, concentrates on two main areas of telecommunications: signal and transmission theory. A short section on switching systems completes the broad picture on telecommunication systems engineering.

An important element of the book is the inclusion of numerous exercises, while a novel feature is the provision of outline solutions designed to bolster students' confidence and to channel their efforts in the right direction.

Although this book is mainly a reference book with exercises, the text is clearly and concisely presented. The author skilfully covers the ground from the basic knowledge required of the subject to the latest techniques in an interesting and informative manner. In places, he discusses techniques in advance of those currently being used.

The author's style of writing makes the book pleasurable to read. While all the points are consummately covered for the more serious reader, the author uses the exercises to guide his student readers towards their particular topics in practical ways.

However, the treatment of exchanges is somewhat disappointing. The author did not intend to cover the topic in any depth, but, in a book purporting to cover telecommunications, only one paragraph in the opening section is devoted to digital switching before Strowger systems and gradings are discussed in the next section. Thereafter, emphasis is placed on traffic theory, while the exercises concentrate almost exclusively on this area.

D. WRENCH

Principles of Secure Communications Systems.
Don J. Torrieri.
Artech House Inc. xii + 453 pp. 180 ills. £61·00.

This textbook, which is a new edition of the book published in 1981 called *Principles of Military Communication Systems*, deals comprehensively with the major communication signal processing techniques and algorithms essential in the design of effective secure radio communication systems. As an expansion of the earlier edition, this new edition maintains a strong military communication theme. Although particular emphasis is given to radio communications, some of the text has direct relevance to line systems and, indeed, to civil communication systems for which rejection of strong channel interference or the need for information integrity is of paramount importance.

In recent years, there has been a significant increase in the number of quality textbooks covering, with differing degrees of specialisation, aspects of security in communications such as spread-spectrum signalling, cryptography and adaptive antenna systems. In this book, Torrieri has successfully combined these important areas of secure communications, and given them added coherence and relevance to current practice by infusing material on supportive techniques; for example, both fundamental and sophisticated error-control coding. His treatment is also enhanced by the inclusion of methods of intercepting radio signals, since the designer of would-be secure radio communication systems must take cognisance of the potential for and limitations of hostile jamming.

The presentation of the book is aimed at practising engineers and post-graduate students. Consequently, the level of mathematical treatment is quite high in several sections in which quantitive analysis is required. The author has adopted a direct factual style of presentation rather than a tutorial form. The book has not been written as an easily referencable text, but it does cover a wide range of topics, usually in sufficient detail to give an adequate appreciation of the underlying principles to enable the reader to comprehend other more specific treatese. A good balance is achieved between the theory and fundamental features of systems, with some sections giving interesting insights into operational practice. The result is a book which brings together a range of what are commonly considered to be specialistic subjects into one text and which is complementary to many other books on secure communications.

Brief descriptions of the contents of each chapter follow.

In the first chapter, the ineffectiveness of analogue modulation methods in resisting strong interference is demonstrated in a simple manner. Performance analyses are presented for several potentially interesting narrow-band digital modulation schemes when subjected to white Gaussian noise and tone interference. After a brief introduction to pulsed jamming and interleaving, an informative introduction is given to soft-decision and hard-decision error-control coding, including error performance curves for practicable block, convolutional and concatenated codes.

Chapters 2 and 3 are dedicated to spread-spectrum (SS) communications; in both theory and practice. Chapter 2 is specific to direct sequence (DS) SS systems and therefore, after a clearly presented introduction, topics such as pseudo-random sequence correlation properties, code-division multiple-access and tau-dither loop and delay-locked loop code tracking systems are covered. Error performance analyses are presented for a binary phase-shift keying (PSK) DSSS system operating under three different modelled jamming conditions: Gaussian stationary-process, tone-interference and 'nearly exact' models. This chapter clearly describes the process and practice of code acquisition. Chapter 3 deals exclusively with frequency-hopped (FH) SS communications, initially differentiating between fast and slow hopped systems and between the use of direct and indirect synthesis techniques. After showing the potential disruptiveness of repeater jammers to FHSS communications, an illuminating analysis gives the word error performances of fast and slow FH systems when partial-band interference is experienced. Clear, but often short, presentations are made on: partial jamming of MFSK; comparison of FH/CPFSK and FH/DPSK; repeater and partial-band jamming of FH multiple access; code synchronisation and hybrid systems. Highly instructive expositions are given in both chapters 2 and 3 of the applications and benefits of a comprehensive range of forward-error-correcting codes in SS systems experiencing white Gaussian noise and Rayleigh fading.

The fourth chapter is devoted to radio signal interception. As a primarily descriptive chapter, it provides a good introduction to the many techniques used in the three main processes of interception: detection, frequency estimation and direction finding.

Chapter 5 addresses a very wide range of signal-processing techniques and convergent algorithms relevant to adaptive antenna systems. It provides a well-structured and instructive compendium of ideas on the rejection of interference by filtering spacially. The major types of systems described and analysed are: sidelobe cancellers; adaptive null-steering antennas and adaptive noise cancellers. Over half the chapter is dedicated to providing the background theory to and definitions of the MSE, LMS and LS convergent algorithms employed in the adaptation of these antenna systems; for example, the Widrow, the Howells-Applebaum, the Frost and the recursive algorithms.

The final chapter deals with the fundamental principles of cryptography. Block, synchronous and auto-key ciphers are described. Error probability bounds are developed for block and stream ciphers. Other areas of importance covered include the degradation due to cryptography, use of error-correcting codes and the disruption caused by synchronisation loss due to pulsed interference.

In summary, this book covers well a broad area of knowledge on security in radio communications and is complementary to most other textbooks on this subject. In an attempt to maintain a broad scope the author has had to compromise some aspects of presentation, most notably: the brevity of some sections impairs clarity; there are no summaries at the end of each chapter and the book lacks a glossary. Despite these shortcomings the book is recommended, not just because it is a good introduction to this quite new and expansive area, but also because it gives a balanced view of advanced topics.

E. MUNDAY

The Handbook of Antenna Design, Volumes 1 and 2.
Edited by A. W. Rudge, K. Milne, A. D. Olver, and P. Knight.
Peter Peregrinus. Vol. 1 xii+708 pp. 445 ills. £42·00. Vol. 2 xi+945 pp. 717 ills. £68·00.

The term *handbook* conveys a fairly wide meaning, though in this case the two volumes are by no means in the literal category of the term. In total, somewhat over sixteen-hundred pages are devoted to antennas, their operation, design and application. The aim of the books, as outlined in the prefaces, is to bring together the expertise of a generation of workers in a form which would act as a definitive reference for any engineer engaged in the field.

The first volume, devoted to microwave antennas, would primarily be of interest to those starting in this field of work or those wishing to broaden their outlook.

The early chapters of this volume by Professor A. D. Olver deal with the basic properties of antennas, and the author is to be commended on his presentation of the basic physics of the devices and the general outline of the various properties of antennas. The text on quasi-optical antennas in Chapter 2 becomes deeper and more complex, and I

suspect this section will be tackled only by students of the subject. This chapter is heavy on algebraic expressions which, while being fairly familiar, are of little immediate interest except for academic use in textbooks or in the more erudite areas of antenna design. However, if you wish to understand the various quasi-optical design methods and their application, then this is the section to read.

The following chapter deals with the more practical side of the design of quasi-optical antennas and, I suggest, would be of particular use to a system designer or indeed would serve as a review of the subject areas. It contains clear examples and solutions to problems and uses considerably less algebra than the previous section. There are several good graphical presentations.

The next chapter, on primary feed antennas, is again of direct help for practical, everyday problems encountered in design. Hybrid antennas (the author includes the definition) are dealt with in Chapter 5. This class of antenna is a glorious mixture of technologies; some of these may seem inelegant, but they nevertheless represent a major work area. Multiple-beam antennas are of prime importance in satellites and world-wide communication; the author here gives a good description of this subject.

Up to this point, Volume 1 deals almost exclusively with relatively high-gain antennas. Chapter 7 deals with a small application area of low- and medium-gain antennas. There is little mathematics but the explanation of the subject is clear and concise.

Having designed your antenna, how do you prove it? The last chapter of Volume 1 amply describes the various measurement methods that are needed to test an antenna. Although containing a little algebra which some technicians who perform the measurements may baulk at, this chapter is essential reading for those who exist in the practical world.

As a handbook, one might expect the answers to many problems with supporting algebra and formulae. While this is true to a certain extent, there is much evidence of particular authors revelling in their subject to the detriment of clarity. However, work presented is of a high quality and should prove useful over a wide area of work.

Volume 2 covers array antennas, radomes and all other classes of radiators (VLF, LF, MF, HF, VHF and UHF). Array technology can be extremely complex as it is a facet of the classical many-body problem. The subject is split into several classes with the features and properties of each class set out.

The first two chapters by R. C. Hansen represent clear informative works and serve as a good review of the subject. Conformal areas in Chapter 11 (the chapters are numbered consecutively throughout the two volumes) are described as arrays that are non-planar. More particularly, these are antennas which can conform to any surface shape.

Circular arrays represent in some ways a classic subject, in that the symmetry can simplify the algebra (not to say the physics) considerably. Chapter 12 is a good description of the subject by a recognised authority in the field.

Having covered what can be considered as static arrays, the book goes on to cover array signal processing in the next chapter. This is the manipulation of the array signals to provide scanning or some such property to derive information on directional parameters. A typical example of this is the synthetic aperture antenna used in radio astronomy.

Radomes are represented by much of the profession as something of a black art. This subject is heavily dependant on materials technology, and, until recently, development has been restricted. However, certain application areas have reached maturity and the subject has received much attention over the years. I have found this chapter (Chapter 14) of particular use in the feasibility stage of a project.

Having personally had little to do with antennas other than at microwave frequencies for many years, I found the chapters dealing with the lower frequencies to be a good source of material. From the age distribution of the references, the subject does not appear to have attracted a great deal of funding in recent years (perhaps as the frequencies of interest have increased).

Compared with Volume 1, the second volume gives the impression of being less unified. It is difficult to quantify, but I daresay it comes about from the sheer scope of the work.

To summarise, these two volumes represent a mammoth effort of endeavour, and display the contributions of a vast number of workers over the last twenty years or so. These are not the sort of handbooks one would use when confronted by an antenna. More appropriately, they are of significant value in education and the laboratory. The information they contain makes them ideal for the student and the design engineer. I would recommend these volumes as general reference books for all those engaged in the field of antennas, communications and radar.

D. J. EDWARDS

Signal Recovery from Noise in Electronic Instrumentation.

T. H. Wilmshurst.

Adam Hilger Ltd. vii+193 pp. 166 ills. £17·50.

The book, which covers a somewhat specialised subject, is intended for undergraduate electronics engineers and design engineers of measuring instruments. The text is amply supported by many diagrams and illustrations, and the supporting mathematical content is useful, but the book does not depend too much on this. Although the book can be read from start to finish as, for example, in a course of study, many readers will use it as a reference source; and, to this end, it is conveniently divided into 10 chapters each with indexed subsections.

The casual reader interested in electronics and telecommunications will find something of interest in the specialised techniques available, which in most cases can also be applied to measuring instruments in other fields of application. The types of signals of interest may be generated by sensors or test sources and may be steady state, repetitive or one-shot, where the parameters to be measured could be amplitude, timing or pulse shape. The types of noise which make signal recovery and measurement difficult are varied. Uniformly distributed white noise is most common in telecommunications, but $1/f$ noise can also be a problem. Other forms of unwanted noise are offset, drift and interference, and ways in which the various design problems can be solved are presented.

The first section of Chapter 1 provides a useful overview of the whole book before the author moves on to explain with the relatively simple concepts of low-pass filter noise reduction and visual averaging of waveform displays; it is surprising how good the judgement of the human eye can be and the author explains why this is so.

Chapter 2 deals with multiple time averaging as a way of reducing the effects of drift, and then extending the averaging time to obtain a low white-noise error. Another method of reducing drift and offset, covered in Chapter 3, is to employ phase-sensitive detection. This involves the use of transducers that produce an AC output, and therefore permit AC coupled amplifiers that do not respond to low-frequency effects to be used.

Chapter 4 introduces the frequency-domain or spectral concept; the following three chapters give an alternative treatment of the multiple time averaging and phase-sensitive detection methods with particular emphasis on the reduction of white noise and $1/f$ noise.

The signals to be measured can be displayed in an analogue manner on a meter or oscilloscope, but an alternative method is to code digitally the signal for computer storage and further processing as described in Chapter 8. In this way, repetitive signals can then 'grow' out of the noise, which, because of its random nature, grows more slowly than the wanted waveshape.

Chapters 9 and 10 deal with certain types of pulsed and transient signals. Of particular interest is the case where the shape of a transient is known, but the amplitude—the factor to be measured—is not. Here, a 'matched filtering' process is shown to give minimum noise error. Another important case where the shape of the signal transient is known, but the factor to be measured is not, is the time of occurrence. The matched filtering technique can be modified for this measurement. In addition to reducing the effects of white noise, which is of particular interest in telecommunications. the book pays special attention to drift and $1/f$ noise instrumentation.

P. W. Lines

Integrated Circuits and Microprocessors.
R. C. Holland.
Pergamon Press. x + 235 pp. 197 ills. $14·50.

This is a well-written compact book that is suitable for the newcomer to micro-electronics. It includes a fairly large amount of material at an elementary level which provides a sound foundation for more detailed study. Although it does not go into the subject in depth, its choice of topics is very wide and well balanced. The title aptly describes the contents: integrated circuits of all the common types (digital and analogue), and microprocessors and their support chips (mainly 8 bit but with some mention of 16 bit devices).

The aim of the book seems to be to bridge a specific gap: the one between the theoretical academic student's textbook, and the practically orientated manufacturer's data information sheets. In this it succeeds, and in many areas there is much to admire about this book. Each of the many topics is handled very well in the limited space available. There are 14 chapters: one on integrated circuit (IC) fabrication, five on digital ICs, three on analogue ICs and five on microprocessors. The book is aimed at students who have only a rudimentary knowledge of electronics, and provides a broad treatment, almost an overview of the subject.

The best part of the book is the well-balanced treatment of micro-electronics. For example, the coverage of integrated circuits is comprehensive. It begins with the manufacturing processes. The next chapter, which is on 'Logic Families', starts at simple gates made with switches before it progresses through all the other important logic ICs: DTL, TTL, ECL, MOS and CMOS. This allows the reader at the end to make a useful comparison between all these families. I^2L is even mentioned at this point to complete the picture. There are copious diagrams, almost every page has one, and the style of writing is highly readable.

The microprocessor chapters major on the Z80, a reasonable choice at this level. The programming examples are not particularly origional but serve their purpose, which is to illustrate the principles involved. The fault finding chapter at the end, a topic often neglected by other authors, is particularly good. The glossary and the TTL IC sheets in one of the appendices (courtesy of RS Components Ltd.) are also a nice touch.

On the negative side, there are a few errors. For example, the 'Comparison of Logic Families' table has some errors in it; frequency response and slew rate are confused, a fact that is rather surprising from an author who otherwise demonstrates considerable depth and understanding. Secondly, the examples of memory devices are dated by today's standards. The principles are well explained, however, so perhaps little harm is done. The exercises for students at the end of each chapter betray its academic origins. Personally, I find these tend to put me off any book, but presumably some readers will find them useful. Also, a few more practical circuits to illustrate the principles described would have been useful. Readers must realise, as well, that if they wish to gain more than just surface appreciation of micro-electronics, then they will have to look around for other books to provide them with the depth give depth that this short text cannot.

On balance, however, this is a book that can be recommended to anyone wishing to delve into the field of integrated electronics and microprocessors for the first time.

D. D. Hornsby

Digital Techniques: Second/Third Level.
C. Kelly.
Hutchinson. 93 pp. 105 ills.

This book is one of a series specifically intended for use by students following Business and Technician Education Council (BTEC) courses. Its content covers the standard units of Digital Techniques at levels II, IIIA and IIIB, but, because of the general nature of these courses, it may be of interest to non-BTEC readers. Each chapter begins with a statement of its aims and contains periodic review sections designed to encourage the student to check his progress and understanding of each section. There are also occasional exercises, and each chapter ends with a number of self-assessment questions.

The most striking feature of the book is its brevity, having only 75 pages of text designed to cover the material of a course which normally lasts 90 hours. This means that some of the topics have been covered in just sufficient detail to meet the specific objectives of the BTEC syllabus. With extra information and more examples throughout, the book's usefulness to students following all types of electronics courses would have been considerably increased.

After a brief introduction to analogue and digital systems, the first two chapters deal with combinational logic circuits. British Standard symbols are used throughout. Circuit minimisation techniques using both Boolean algebra and Karnaugh mapping techniques are covered, together with the application of universal gates to logic circuit design.

Most of the examples of practical circuits in the book are based on transistor-transistor logic (TTL) designs, although complementary metal-oxide semiconductor (CMOS) alternatives appear in a number of places. Emitter-coupled logic (ECL) gates are mentioned in the chapter on logic families, but the treatment has been simplified so much that the basic facts, such as their common use of a negative supply voltage, are not mentioned. Generally a helpful approach to logic circuits has been adopted which blends both the theoretical operation of the devices with the practical pin connections of the real chips.

The second half of the book contains chapters on bistable circuits, counters, registers and memory devices. Here the depth of treatment is adequate but a little extra explanation would in many places have been of great benefit to students. For example, no description of the basic NAND gate bistable circuit is included.

Overall the book is well written and presented but would need to be studied as part of a formal course on digital electronics. It is most useful as an alternative set of lecture notes for students studying a BTEC course rather than an in-depth treatment of the subjects covered.

D. Turner

British Telecom Press Notices

Databank Card

A databank card the size of a credit card and holding 800 pages of text or eight television pictures will be test marketed by British Telecom (BT) this autumn. Initially, BT will be aiming its Recall Cards at four market sectors:

- Health care, for storing medical records, medication usage, and vital personal data on blood group, allergies, and conditions such as diabetes.
- Software distribution, offering up to 2 Mbyte of addressable data with intrinsic security and encryption and detectable copying.
- Financial transactions, holding an individual client's records on encrypted data with high security and capable of easy update.
- Access control, providing a tamper-proof personnel security device capable of storing an individual's biometric details.

Data is imprinted in the card either photographically at the time of manufacture or by laser beam later. Old data can be readily cancelled by overwriting. The cards are intrinsically secure and difficult to corrupt either accidently or deliberately. They are unaffected by climate, magnetic or electric fields, exposure to light or radioactivity, or frequent handling.

Attempts to copy data inserted at the time of manufacture can be detected, and the medium itself is tamper-proof. High security encryption can also be used to give further improvement in the integrity of the Recall Card.

The cards will be sold under licence from the Drexler Technolgy Corporation, of Mountain View, California. BT will also offer a series of readers and reader/writers for the card, and will design and implement total systems for users covering a wide variety of information technology applications.

Recall Card

A particular feature of BT's service will be the ability to integrate applications of the Recall Card with telecommunications networks. To this end, the card may be used with BT's M5000, M6000 and M7000 ranges of data terminals.

Electronic Yellow Pages Goes Live

British Telecom's Electronic Yellow Pages (EYP) went live on 8 January 1987; it allows most on-line communicating terminals in the UK and abroad free access to a database of Yellow Pages advertisers. Information on EYP will initially cover the whole of London, Reading, Guildford, Watford and St. Albans. The information will be broken down by classification headings as in the printed books. EYP is available to users free of subscription and computer time-based charge. Connection to EYP can be either via a Gateway on Prestel or by direct dialling over the public switched telephone network at the normal tariff.

Full instructions on how to access EYP will be published in all Yellow Pages books where EYP is available. All Yellow Pages display advertisers will be entitled to 'space' on the system to publicise fast-changing information such as availability, pricing, and special offers about their products and services, as well as a listing of names addresses and telephone numbers. Businesses taking out advertising at semi-display level will automatically be listed. This means that for the first time Yellow Pages advertisers can publicise time-sensitive information.

Advertisers' initial response to EYP is extremely favourable. For example, more than 25% of the display advertisers in the London South West Yellow Pages are taking part in EYP.

The service will carry listings (names, addresses and telephone numbers) on all areas operating EYP. Information on products and services will be added to these listings on a book-by-book basis coinciding with the local distribution of Yellow Pages.

EYP can be accessed by any terminal that uses the ASCII communicating protocol and is equipped with a modem and the appropriate communication software. Terminals that fall within this category are personal computers and Prestel sets.

British Telecom to Provide Network Management for Government Telecommunications Network

British Telecom (BT) is to install the computer system to be used for managing the UK's largest private voice network—the Government Telecommunications Network (GTN). BT's Communications Facilities Management (CFM) unit, launched last October, has won a contract from the Central Computer and Telecommunications Agency (CCTA) under which it will supply its LinesMan computer-based system and network management products and services. BT will also act as project manager for the installation of the system. Installation is expected to be completed by the Spring of 1988.

The GTN interconnects Government offices in London with regional and local offices around the country. At present, it consists of about 460 private branch exchanges (PBXs) serving some 170 000 extension telephones. The PBXs are interconnected by a network of tandem (call-forwarding) exchanges, linked by 2 Mbit/s digital private circuits. These exchanges route calls between extensions in different parts of the country.

BT's LinesMan system will run on a central processor at CCTA headquarters in London linked to microcomputers installed at each main tandem exchange. These will log calls and provide remote access for configuration changes, alarms and supervision. Call data stored at each tandem exchange will be transferred to the central processor at regular intervals to provide an analysis of the flow of calls through the network during the working day. This analysis will also enable the CCTA to provide accounting information so that the cost of calls can be correctly allocated to the relevant departments. The central processor will store a multiplicity of information about the network and its PABXs, and will enable changes to be made to switch configuration from the headquarters management centre. The LinesMan system will also house, collate and analyse faults, establish fault and maintenance support records, and provide a wide range of network administration data.

In addition to the LinesMan network management system, BT's CFM unit will supply network diagnostics equipment to check circuits for availability and quality of transmission. Central autodiallers will generate test calls through the night, and monitor the performance of the network from responses to the calls provided by local transponders. There will also be a help-desk facility for network users, and the CFM unit will train staff in the configuration and management of the system.

Link Network Goes Fully Live

The central switch for LINK, a nationwide network serving more than 1000 automatic teller machines for banks and building societies, has been successfully implemented for LINK Interchange by British Telecom (BT). This will provide facilities for cash withdrawal and account checking for millions of customers of the members of LINK Interchange Network Ltd. These are National Girobank, Co-operative Bank, Nationwide Building Society, Abbey National Building Society and Funds Transfer Sharing, a consortium of more than 20 financial institutions.

The LINK system consists of a central computer connected to the host computers of each LINK member. This enables the customers of any LINK organisation to use a LINK card in any cash dispenser carrying the distinctive LINK symbol.

The LINK contract was awarded competitively last year to British Telecom Applied Technology (BTAT), the commercial computing services division of BT. BTAT has designed, developed, installed and implemented the LINK switch and telecommunications network in a phased programme which began last November. It will now manage and operate the LINK switch for a minimum of three years, during which both use of the system and the range of facilities offered will grow significantly. BTAT designs and manages complete computing schemes, among them the world-beating import and export cargo clearing scheme, covering Heathrow, Gatwick and Manchester airports and the major English seaports.

The focal point of the LINK network is a triple processor Tandem TXP computer, one of the Tandem series of 'Non-Stop' fault tolerant mainframes. This is connected to LINK members' computers through BT's KiloStream digital private circuits. The Tandem computer, which acts as a switch to route data between the members' machines, runs on Connex electronic-funds-transfer applications software supplied to BTAT by its subcontractor, Systems Designers. The Connex software, developed by A. O. Smith Data Systems Inc., provides the interface to the LINK members' host computers, a mixture of IBM, Tandem and Stratus machines, and accommodates the members' different operational procedures.

Notes and Comments

REVIEW

Industrial action by British Telecom (BT) engineering staff was brought to an end in February by a two-year pay and conditions agreement between the company and the National Communications Union (Engineering). Agreement was also reached in January between BT and the Society of Telecom Executives on a pay and efficiency package for BT managerial and professional staff.

In January, BT announced the start of a trial scheme whereby 2500 customers in the City of London are to be offered more detail on their telephone bills. Bills will show details of all dialled calls of 10 units or more. Details to be included on the bill will be date and time that the call is made, the number called, the duration of the call and the charge for the call. The cost of other calls and the number of units used in making them will be shown as a bulk figure. The six-month trial will cover about 10 000 lines on three exchanges in the City of London.

About 35 000 customers in parts of Bristol and Bath have been offered itemised bill details of all trunk and international calls since 1983 in a free trial operating on older analogue exchanges. The City of London trial employs the latest digital exchange technology which is being introduced nationally as part of BT's modernisation programme.

On 4 February 1987, BT opened its new office in San Francisco with a live videoconference link from London to the West Coast of the USA. Mr. Iain Vallance, Chief Executive of BT, spoke via a satellite link from London to customers 5360 miles away in the San Francisco Hilton. He described the opening of the new office as proof of BT's committment to its overseas customers in its aim of becoming the world's best telecommunications company. BT opened its first USA office in New York in mid-1984, and the opening of the San Francisco office is the next step in BT's plans to establish offices in key business areas throughout North America.

Dr. Roger Heckingbottom, Head of the Materials Division at BT's Research Laboratories, Martlesham Heath, has been appointed Honorary Professor in the Departments of Physics and Materials Science and Mechanical Engineering at University College, Cardiff. The appointment runs for five years.

At Cardiff, he will be contributing in particular to research on molecular beam epitaxy of semiconductors—a new venture physics supported by the Welsh Office. More generally, he will be advising on materials research for optical communications and drawing on his experience on Science and Engineering Research Council and Department of Trade and Industry committees to help tackle the problems of funding research of industrial relevance.

BT's Applied Technology (BTAT) computer services division is to develop and supply a new automated cargo control system for airlines, agents and HM Customs based at Gatwick, Heathrow and Manchester Airports.

The new system, worth about £10M over the next five years, will be known as *Air Cargo Processing for the 90s* (ACP90). It will run on large new IBM compatible microframes and will be developed from the current ACP80 system, also produced by BTAT. In addition to providing automated Customs entry and clearance facilities through Customs DEPS computers (which BTAT runs for Customs), ACP90 will enable users to control and manage freight inventories and send messages to other users.

BTAT will develop the new system and phase it in over several years, to ensure vital continuity of service. BTAT will also provide, manage and service the system hardware and its associated networks, which currently serve more than 500 users, and is continuing to grow.

As part of their agreement for providing the Isle of Man with modern digital services, BT and Manx Telecom have jointly placed a £3M contract with STC to provide a 90 km optical-fibre cable link to the Island from Cumbria. The cable is expected to come into service at the end of the year. The new cable, which will augment analogue and digital microwave radio links with the Island, will have six fibre pairs, of which five will be in use immediately, and will operate at 140 Mbit/s.

The new cable is the latest step in converting the Isle of Man to digital operation by 1990. Manx Telecom, the BT subsidiary responsible for running the Island's telecommunications services, has already started installing optical-fibre land cable to link its exchanges. It is to install 11 digital local exchanges; the first, a 2000-line AXE10 unit, is due to come into operation in Douglas before the end of this year.

On 26 February, British Telecom Mobile Communications (BTMC) and Plessey demonstrated a digital cellular radio link over BT's integrated services digital network (ISDN). This was the first time that digital cellular service had been demonstrated over a public digital network. The demonstration focussed on a mobile camera unit providing a slow-scan television link to a central control point. Such a service could benefit security companies and conference organisers.

The link was the latest stage in a joint project which is part of the UK's research into a pan-European digital cellular radio network, scheduled to be operational by 1991. The joint project is being co-ordinated by the UK Cellular Radio Advisory Group, which is chaired by the Department of Trade and Industry and includes representatives from BT, GEC, Marconi, Phillips, Plessey, Racal and STC. BT's input into the project was co-ordinated by its research centre at Martlesham Heath.

The trial demonstrated the progress made by the UK in developing practical mobile applications for the ISDN. Slow-scan television represents a preliminary stage in the development work, and further advances will lead to combined voice and data transmissions.

In February, British Rail signed a contract with BTMC to install 200 trainphones using the Cellnet cellular system on its InterCity train services. The order was BT's largest yet for cellular telephones. British Rail plans to install the telephones, which will use BT's familiar green Phonecard system, on InterCity routes over the next two years. BT has already supplied nine System 4 trainphones to British Rail on InterCity Pullman trains serving London, Liverpool. Manchester, Leeds, Newcastle and Blackpool, and these will be converted from cash to Phonecard payments. The sale of Phonecards from train buffet cars is currently being trialled on some InterCity routes, amd it is hoped that this will become a national service.

In March, Plessey reported that it had won the first major export contract for System X. The multi-million pound contract has been awarded to Plessey by the Colombian telephone authority and involves the supply of 13 telephone exchanges which includes 68 000 lines of System X equipment. The award also includes transmission equipment for the interconnection of these exchanges and existing equipment.

BT has been awarded a contract jointly with Pace Communications (UK) Ltd. to supply a radio communications system to the London International Financial Futures Exchange. The initial order is for a pilot system operating on 16 channels.

In March, BT announced that it had ordered 25 000 new-style electronic telephones as part of the final stage in its programme to modernise the UK's 77 000 public payphones. The contracts, worth £23M, are for 15 000 electronic payphones which accept all coins from 2p to £1, return unused coins at the end of a call and automatically report their own faults, ordered from Plessey Telecommunications Products Ltd. of Liverpool; and 10 000 Cardphones which operate on holographically-encoded pre-paid Phonecards, from Landis and Gyr of North Acton, London.

PUBLICATION OF CORRESPONDENCE

A regular correspondence column would make a lively and interesting feature in the *Journal*. Readers are therefore invited to write to the editors on any engineering, technical or other aspects of articles published in the *Journal*, or on related topics. Letters of sufficient interest will be published under 'Notes and Comments'. Letters intended for publication should be sent to the Managing Editor at the address given below.

DISTRIBUTION OF THE JOURNAL

Many IBTE Members and other employees of British Telecom and the Post Office who subscribe to the Journal by deductions from pay have still not yet supplied their home addresses to the IBTE Administration Office so that copies of the *Journal* can be sent directly to their homes. Back issues of the *Journal* since October 1985, when this new method of distribution was started, are being held in store for these Members and readers until this information is received. Members and readers are asked to remind their colleagues to supply this information as soon as possible if they have not already done so; a form for this purpose was included with the April 1985 issue of the *Journal*. These Members and readers will then be sent the back issues and all future issues to their home address. Any enquires about this notice should be directed to The IBTE Administration Manager, Room 107 Intel House, 24 Southwark Bridge Road, London SE1 9HJ; Telephone: 01–928 8686 Extn. 2233.

CONTRIBUTIONS TO THE JOURNAL

Contributions of articles to *British Telecommunications Engineering* are always welcome. Anyone who feels that he or she could contribute an article (either short or long) of technical, managerial or general interest to engineers in British Telecom and the Post Office is invited to contact the Managing Editor at the address given below. The editors will always be pleased to give advice and try to arrange for help with the preparation of an article if needed.

Educational Papers

The Editors would like to hear from anyone who feels that they could contribute further papers in the series of educational papers published in the *Supplement* (for example, see the paper entitled *Digital Multiplexing*, included with the April 1986 issue of the *Supplement*. Papers could be revisions of British Telecom's series of *Educational Pamphlets* or, indeed, they could be completely new papers. It is intended that they would deal with telecommunications-related topics at a more basic level than would normally be covered by articles in the *Journal*. They would deal with, for example, established systems and technologies, and would therefore be of particular interest to newcomers to the telecommunications field, and would be useful as a source for revision and reference and for those researching new topics.

Intending authors should write to the Deputy Managing Editor, at the address given below, giving a brief synopsis of the material that they would like to prepare. An honorarium would be offered for suitable papers.

Guidance for Authors

Some guidance notes are available to authors to help them prepare manuscripts of *Journal* articles in a way that will assist in the uniformity of presentation, simplify the work of the *Journal's* editors, printers and illustrators, and help ensure that authors' wishes are easily interpreted. Any author preparing an article is invited to write to the Managing Editor, at the address given below, to obtain a copy.

All contributions to the *Journal* must be typed, with double spacing between lines, on one side only of each sheet of paper.

As a guide, there are about 750 words to a page, allowing for illustrations, and the average length of an article is about six pages, although shorter articles are welcome. Contributions should preferably be illustrated with photographs, diagrams or sketches. Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that is required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Good colour slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organisational level 5, and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

EDITORIAL OFFICE

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Product News

New LAN Products

Shown for the first time at Which Computer? Show at the National Exhibition Centre, held from 17–20 February this year, was the first in a range of Local Area Systems products from British Telecom (BT)—T-Net 1000. T-Net 1000, which is aimed at corporate, government and medium-sized business customers, provides a solution to the information problems suffered by many organisations.

T-Net 1000 is designed to link computing equipment, both locally and to distant services and mainframes. With the use of gateway options, a T-Net 1000 local area network (LAN) provides flexible communications to

- IBM and ICL mainframes (locally or off-site).
- Wide area access via X.21 and X.25 gateways.
- Minicomputers (using VT100 terminal emulation).
- Dial-up services such as Telecom Gold and Prestel.
- Remote T-Net 1000 networks.

Additionally, T-Net 1000 will interwork with future BT products to be announced throughout this year.

An immediate benefit of BT's Local Area Systems is their ability to share resources between a number of separate users. For example, a common pool of printers may be used by a number of personal computers (PCs) and centrally located data is accessible to terminals on the LAN. Thus a collection of individual PC users in a department or company can be linked together in a network with the capability for rapid and efficient communications between terminals.

T-Net 1000 also offers flexibility of use. By employing ARCNET standard cabling (to RG62AU) and a range of network hubs, workstations can be plugged in to the LAN where convenient and rearranged when necessary with a minimum of fuss and recabling. The *de facto* industry standard Network operating software is used to control the network.

The recently announced M5000 series of personal computers combine effectively with T-Net 1000 to provide an integrated system, and a range of applications software is available to support a variety of business operations. These include networked applications such as the new MerlinWord 5000 for word processing, dBASE III Plus for database management and Dataflex for data analysis and report generation.

To assist customers in the introduction and efficient use of T-Net 1000 systems, BT offers before and after sales support. Consultancy services are available to ensure that the initial selection of hardware and software options meet operational needs. For specialist and non-specialist users, a full range of training courses will be available, either on site or at BT centres. Nationwide after sales support is available should problems arise in operation.

Escort 2 + 6

Escort 2 + 6 is a new small switch from British Telecom (BT) aimed at small businesses and self-contained departments within larger companies; for example, estate agents, accountants and dentists, and large firms where small communications centres can be established.

The switch caters for two exchange lines and six extensions and works as a primary switch off its own direct lines or piggy-backed off a main switchboard. Working independently, or off a main PBX, any of Escort's six extensions can ring out or pick up incoming calls.

Escort 2 + 6 comprises an unobtrusive wall-mounted central console unit and one key module for each extension. The system works in conjunction with standard BT telephones, which are simply plugged into the key module, which in turn is connected to the control unit. A range of telephones, tailored to individual needs, can be used so that direct access to many telephone system facilities can be provided without the expense of a special terminal.

Once an incoming call is answered, it can be redirected to any other extension. Thus every extension user can effectively become an operator, transferring calls from either line to any of the other five extensions. This facility is very useful for small busy offices where calls have to be intercepted and transferred to the appropriate person. Alternatively, it may be necessary to check information with someone on another extension or to consult a file away from the telephone. The hold and enquiry facilities of Escort 2 + 6 deal with these situations so that the user does not have to place the live receiver down, thereby transmitting everything going on in the office.

The system can be easily programmed by the user to suit particular office requirements. For example, a boss/secretary operation can be programmed to allow all calls to be filtered through the secretary's extension; alternatively, one or two extensions can be nominated to act as 'operators' screening all incoming calls. If the boss or office manager is particularly busy, line 2 can be designated for his or her exclusive use.

The key modules display clearly to each extension user which extenal lines are in use; outside lines or extensions are accessed at the push of a single button.

Escort 2 + 6

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